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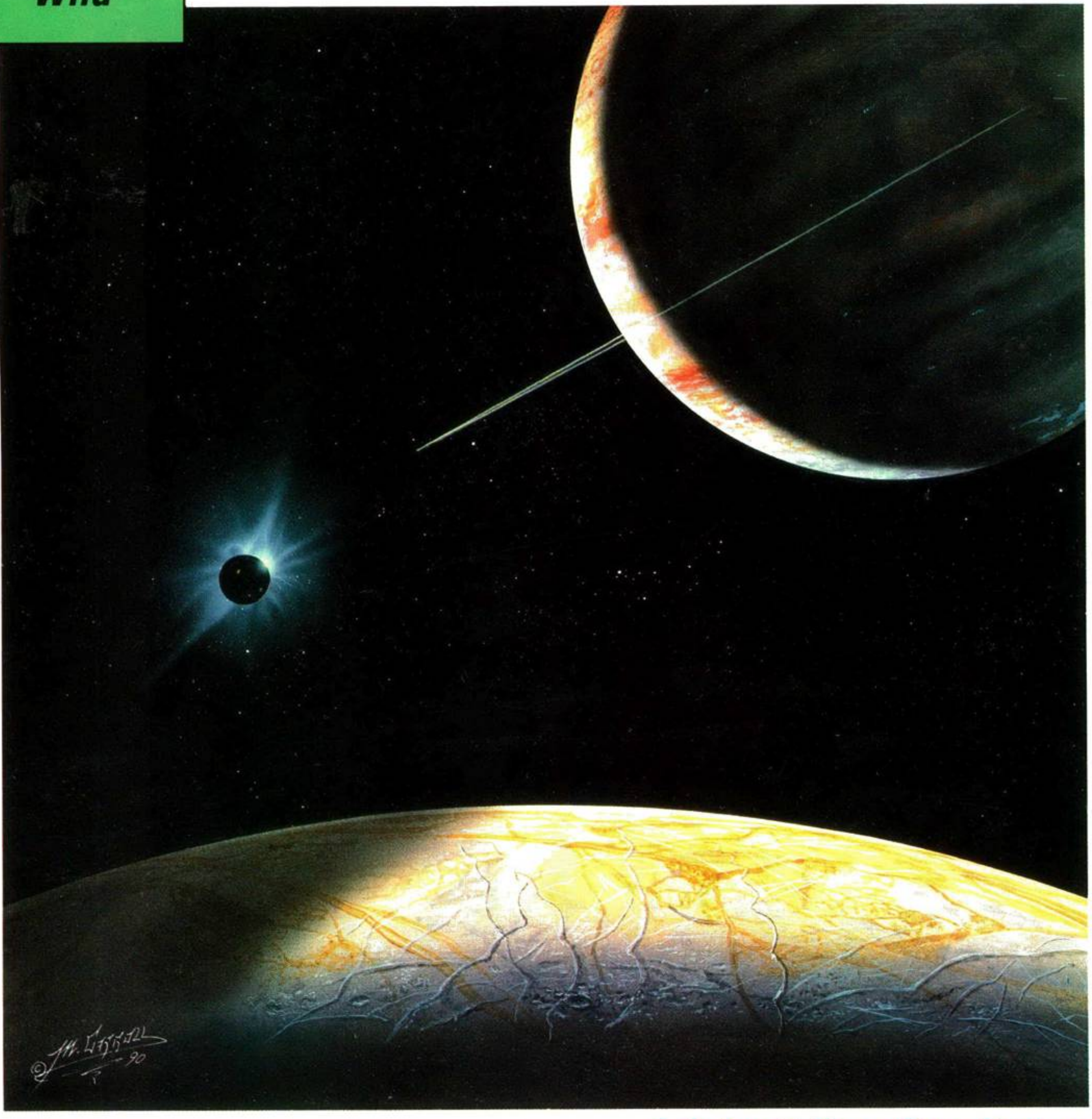

A Solar Eclipse Over Europa

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- **Previous Meade 8″ and 10″ Schmidt-Cassegrain models** may be upgraded to the Smart Drive—see your Meade dealer for details.
- **For complete information on the Meade Smart Drive**—and a point-by-point comparison with competing models—send $3.00 for your copy of the Meade 1990 Catalog #90C.

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Month after month, year after year, in Japan, in Europe, and in the U.S.A., Meade Schmidt-Cassegrains outsell the competition. Why? Among other reasons, compare the hand control/power panel standard-equipment listings of the Meade 8″ 2080/Model 50 (our mid-price-range 8″ SC) with the competition's top-of-the-line 8″ model that sells for hundreds of dollars more! You get more for your money with a Meade.

	Meade 8″ 2080/Model 50	Competing 8″ Model
North-South Operation	Yes	Yes
Map Light	Yes	Yes
2X Corrections East-West	Yes	Yes
2X Corrections North-South	Yes	**No**[1]
Declination Motor	Yes	**No**[1]
RA Slewing	8X speed	**4X** speed
Declination Slewing	8X speed	**No**[1]
Continuously Variable Freq. Control	Yes	**No**
Illuminated Reticle Control	Yes	**No**
Optional Digital Readouts	Yes[2]	**No**
Encoder Outlet	Yes	**No**
AC and DC Adapters	Yes	**No**[3]
Ammeter	Yes	**No**
CAT™ Computer Outlet	Yes	**No**

[1] Optional Dec. motor priced at $170 additional. [2] Includes digital coordinate readouts; digital timer; RA freq. display with King rate; local time; sidereal time. [3] Optional adapters priced at $58 additional.

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"I did not feel it was possible to produce quality Schmidt-Cassegrains to the rigid optical tolerances demanded by an f/6.3 system . . . you have removed all my doubt."

Over the past 12 months Meade Instruments has removed doubts about optical quality from the minds of thousands of serious amateurs. For over that period we have undergone perhaps the most important quality assurance improvement program in the history of the industry. The result: ***never before have amateur astronomers been able to purchase optical systems of the consistently superlative quality that Meade Instruments now makes available.***

This fact has been confirmed over and over again in recent months, as the following letter attests:

August 16, 1990

"Recently I ordered five of your f/6.3 Model 2080/LX6 Schmidt-Cassegrains for classroom/lab instruction at Santa Rosa Junior College. Allow me to take a few moments of your time to praise the quality of your product.

At our College we have a special lab class in which students learn how to observe and photograph through astronomical telescopes. I ordered your f/6.3 LX6 purely for the benefit of obtaining deep sky pictures of nebular objects in 40% of the time required with an f/10 system. However, I must admit I was skeptical about the optical quality of this shorter focal ratio system.

Being an instructor of astronomy for 18 years, as well as an owner of a 6" Roland Christen refractor, I have grown to recognize and appreciate quality optics. Quite frankly, I did not feel it was possible to produce quality Schmidt-Cassegrains to the rigid optical tolerances demanded by an f/6.3 system. Well, you have removed all my doubt.

In viewing Messier objects, planetary detail, and in resolving double stars, all five of your LX6's outperformed the best of our five [competing brand of 8" Schmidt-Cassegrain] telescopes. All five of your instruments showed a smooth optical surface properly corrected as revealed by the "in-and-out-of-focus" star test.

Thank you for developing an instrument which satisfies the demand for both "fast" astrophotography and quality high-power visual work."

Sincerely yours,

Ron Smith, Chairman
Earth & Space Science Department
Santa Rosa Junior College
Santa Rosa, CA

Some weeks later we received a second letter from Mr. Smith:

September 20, 1990

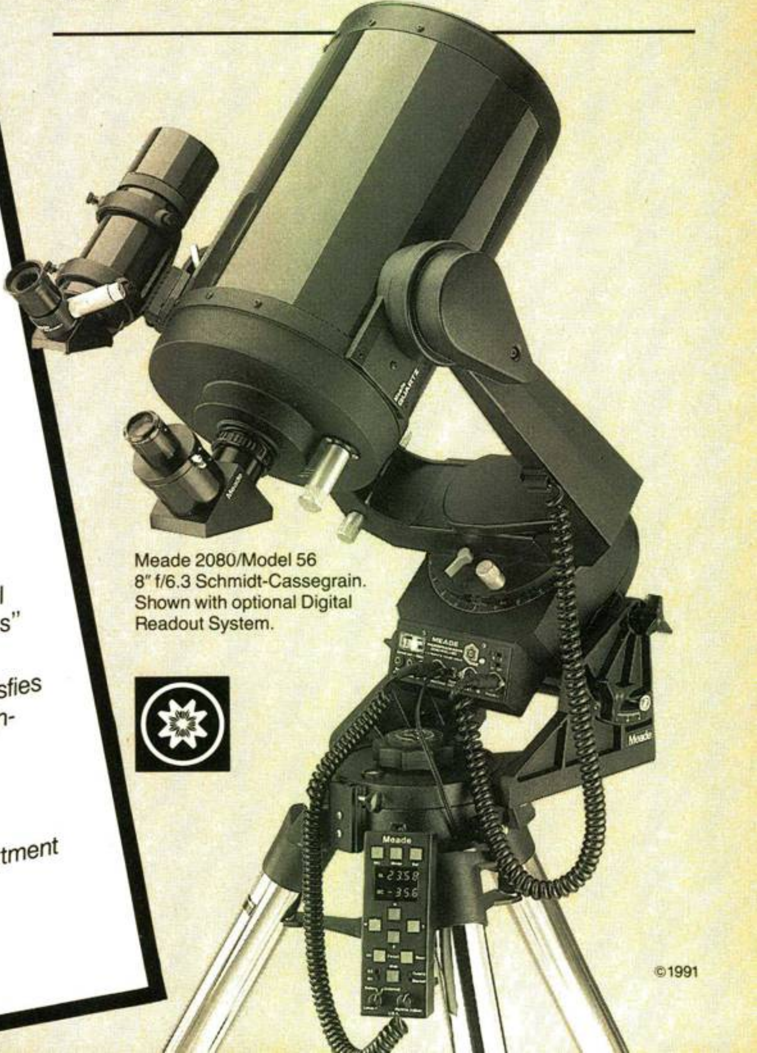
"It has now been three weeks since we took delivery of our Meade 10" f/6.3 Model 2120/LX6 Schmidt-Cassegrain.

Last week, on September 11, my students viewed Saturn and assorted deep sky objects with the Meade 10," side-by-side with a [competitor's] 8" f/10 SCT. Without any exceptions every student preferred the image of Saturn through the 10" f/6.3 compared to the [competing] f/10 telescope.

On a night of good, but not excellent, seeing all of us easily observed Cassini's Division, five satellites, and the subtle cloud band encircling Saturn's disk. On high power deep sky objects, such as the "double-double" in Lyra and the Hercules globular cluster, every student again remarked that the Meade 10" f/6.3 yielded clearer, sharper images.

Thank you for manufacturing this superb optical system."

If you're looking for the finest optics currently manufactured for the advanced amateur, look no further. Look to Meade.



Meade 2080/Model 56
8" f/6.3 Schmidt-Cassegrain.
Shown with optional Digital
Readout System.

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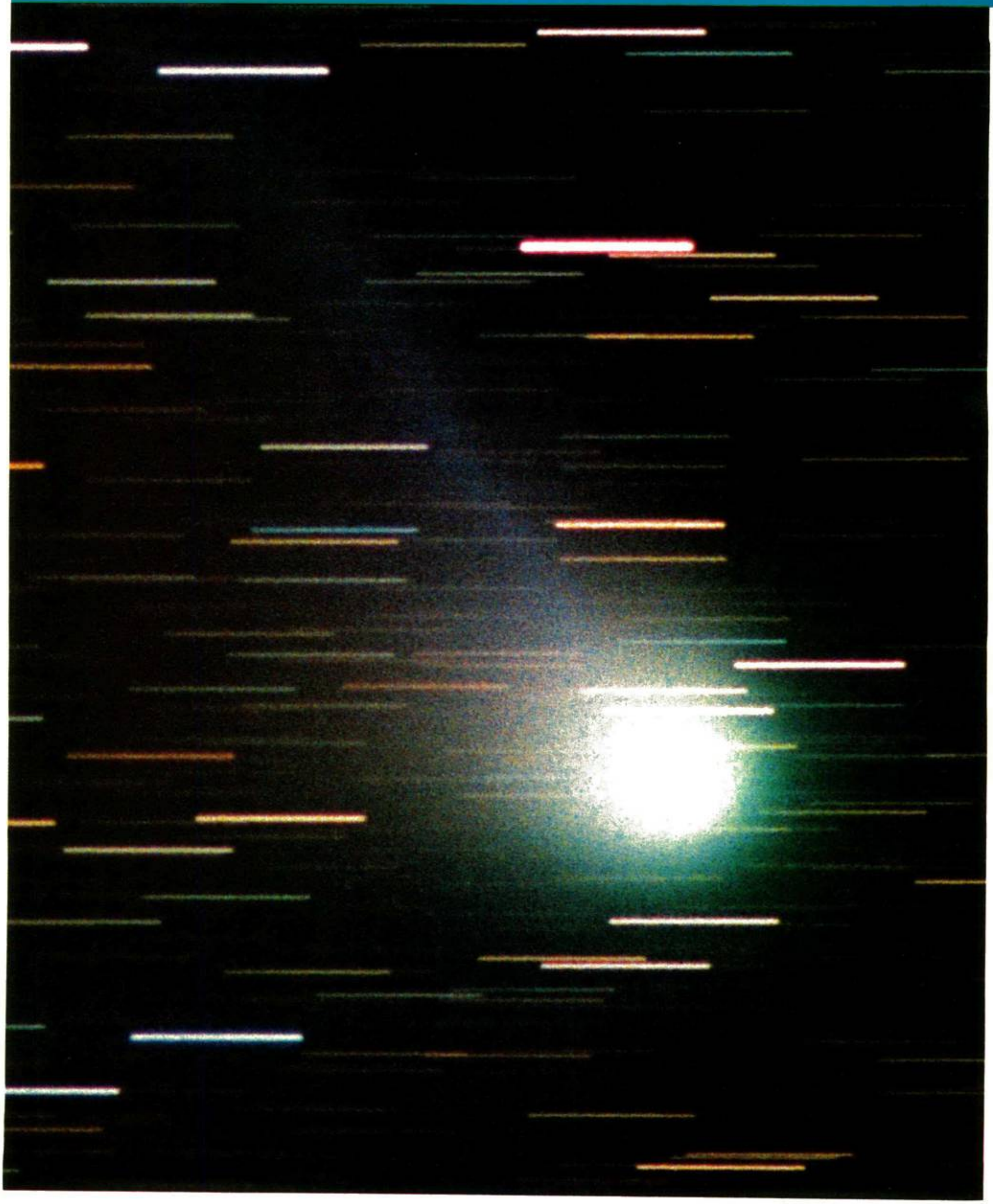
COMET LEVY was the celestial highlight of 1990 for thousands of backyard astronomers as it glided through the summer skies. A portfolio of Comet Levy photos begins on page 76. Photo by Michael Stecker.

ON THE COVER: Jupiter's moon Io eclipses the Sun and casts its shadow onto neighboring Europa, one of many such "mutual events" occurring among the Jovian moons over the next few months. To learn how you can see these eclipses for yourself, turn to page 58. Illustration by Michael Carroll.



ASTRONOMY®

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The Audit Bureau

Behind the Scenes

ASTRONOMY LAUNCHES EARTH

On January 8, a very special extra issue of ASTRONOMY goes on sale. And with that special issue, *ASTRONOMY's Editors Look at EARTH*, Kalmbach Publishing launches a new magazine: EARTH.

We are founding EARTH with a broad charter: to teach the world about planet Earth. Five billion humans call this world their home, yet how little most of us know of it. Too often we forget that our civilization earns its very living on the minerals and metals we take from our planet's crust. Too many of us know nothing of the vast forces that drive the continents and raise the mountains. We forget that we are part of the crucial interaction between Earth's air, water, and life.

And that defines EARTH's job: to tell you about Earth.

Just as ASTRONOMY's editors strive to capture the wonder and beauty of the night sky in the pages of ASTRONOMY, we want our magnificent planet to come alive in the pages of EARTH. EARTH's premier issue, for example, will feature breathtaking satellite photographs of glaciers around the world, from the massive ice sheet in the Antarctic to the rock-strewn valley glaciers of Alaska, photographs that are both beautiful and scientifically revealing.

And because we believe that EARTH's readers will be active travelers, every issue will feature a field trip to a place you can visit and explore. In EARTH's premier issue, for example, you'll walk the rim of Meteor Crater in Arizona with Robert Burnham, ASTRONOMY's Senior Editor and Editor of EARTH's first issue, as your guide.

Furthermore, we're putting an earth-science project you can do at home into every issue. We'll show you how to model the mighty Mississippi with a stream table in the premier issue, and in future issues you'll learn how to build a seismograph, measure Earth's mass, and simulate continental drift in a tabletop model.

The world cannot afford to remain ignorant of Earth. The mission of EARTH magazine is to educate the reader hungry for knowledge. EARTH will be a magazine of fact and solid science, a source of the information you need to understand complex issues such as global resources and mankind's role in climatic change. We trust that, through EARTH, we can help you to enjoy and learn more about the magnificent planet we live on.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

P.S. — For information on how to order the premier issue of EARTH, see the advertisement on page 13 of this issue of ASTRONOMY.

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Letters

The Direction of Amateur Astronomy

I read with interest "Where Is Amateur Astronomy Going?" (Viewpoints, September issue) and particularly enjoyed the discussion of CCD cameras and their effects on the hobby overall.

CCD imaging is really an extension of photography, and I've only recently come to terms with photography as a tool. For a long time it seemed that astrophotographers were concerned, in the main, with the photographic aspects of the hobby. I've heard them talk about film stock and development times rather than wrinkle ridges or colors of the stars. Can countless suns and thousands of light-years really be coldly reduced to a glossy 8"x10"?

Then the penny dropped. Visual observers, I realized, are just as guilty of "collecting" observations. How many satellites of Saturn have you seen? How many Messier objects? Then it began to seem like CCDs are simply the latest additions to the long list of hot-shot accessories with which to win friends and influence people.

Or are they? We all collect observations, just as we collect a set of eyepieces. It's part of the fun — but only a part. The high-tech aspects of amateur astronomy pose a danger not only to the newcomer but also to the seasoned veteran. At an evening class I taught recently one student would not even look at the sky with the naked eye — nothing less than a "large telescope" would do.

Each of the methods of making observations has its strengths and weaknesses. Visual observing, astrophotography, and electronic imaging all serve amateurs well. Comparing them in any sense is really missing the point of what amateur astronomy is all about. — *David S. Conner, Leicester, England*

I enjoyed the discussion of CCD cameras as observing tools in your September Viewpoints. While they have become invaluable for professional research and offer much to the amateur, I feel there will always be a distinction between using such devices and visual observing.

Visual observing is seeing the universe as it is, in real time. "Observing" with a CCD camera is simply collecting photons from an object for manipulation by an electronic machine. How can the two be compared? — *John Kingery, Norwood, Ohio*

I really enjoyed the article on the direction of amateur astronomy. That's exactly the kind of thing we sit around

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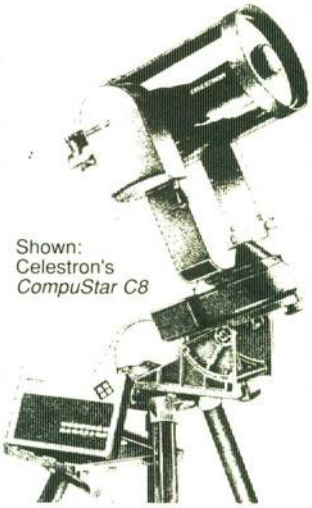

Shown: Celestron's *CompuStar C8*

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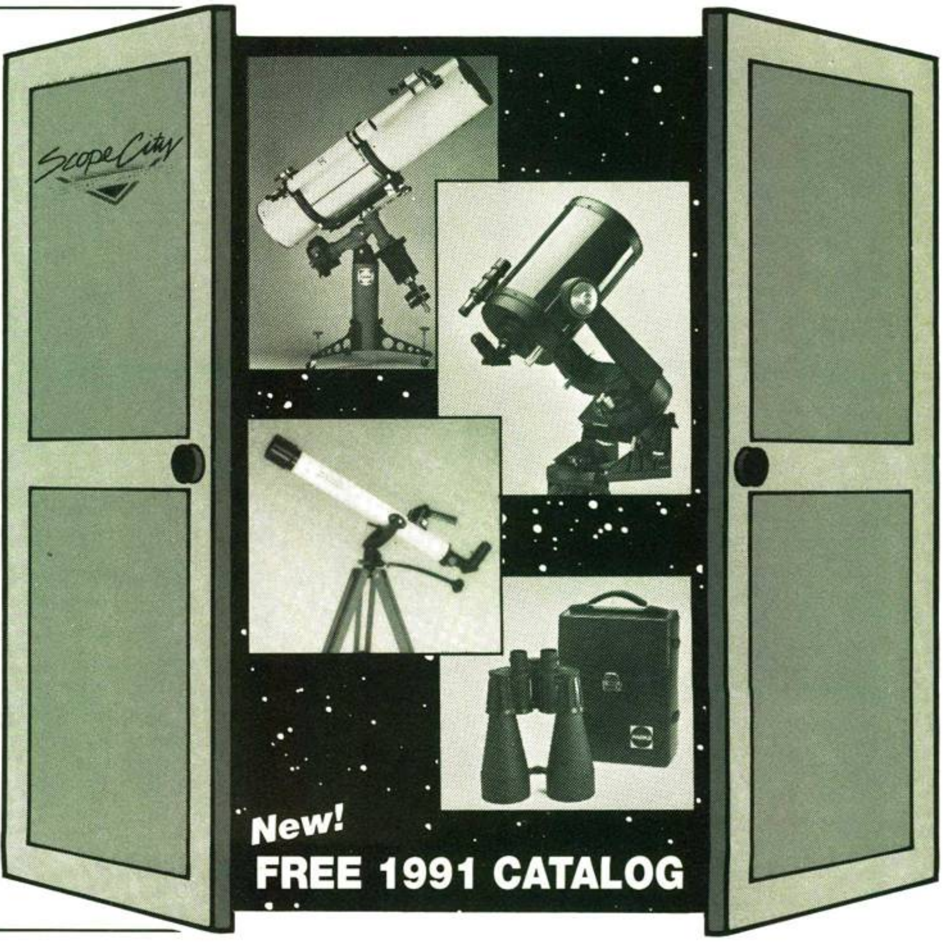

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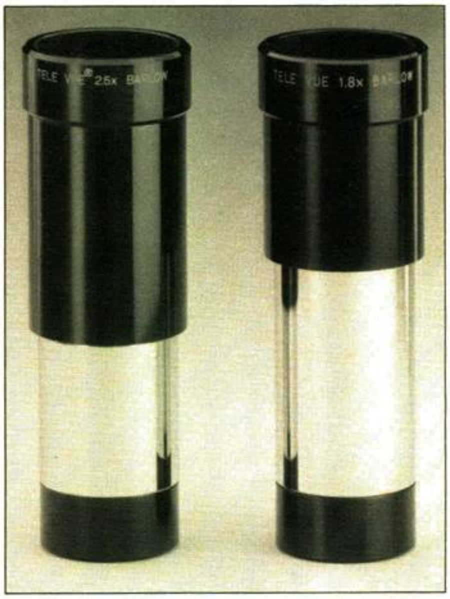

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and discuss in our local astronomy club. As you know, newcomers often feel awkward getting squeezed between hard-core computer freaks and darkroom nuts. Not to mention the heavy, gut-wrenching talk about faint galaxies in Coma Berenices from the deep-sky observers.

In our club we really pay attention to this and try to give newcomers the same kind of experience we remember from our first nights out under the stars. Those magic moments of first seeing Saturn and spotting the Orion Nebula stick with you for years to come.

Astronomy certainly is becoming specialized. No single amateur can get deeply involved in all areas and become an all-around expert. I don't think it matters where astronomy is going as long as amateurs remember that the simple beauty of the sky is supreme to all other considerations. — *Dennis Sørensen, Underup, Denmark*

The Rising Cost of Astronomy

I enjoyed reading Clive A. Cadle's letter about the rising cost of and declining interest in astronomy, especially by kids. I too feel that the rising cost of getting into the hobby is what turns off a kid and his parents when faced with a telescope purchase. They see $2,000 and $3,000 scopes and think they need one of these to enter the hobby. This is ridiculous! I am eleven years old and have been interested in astronomy for over three years. All you need to get into the hobby is a pair of eyes. I enjoy observing simply by identifying constellations, watching meteor showers, and viewing the Moon and planets with a new (and cheap!) pair of binoculars. It's just wrong to claim that you have to have a fat pocketbook to enjoy amateur astronomy. — *Lee M. Hower, Tampa, Florida*

Will the Best 6-inch Scope Please Stand Up?

I greatly enjoy your reviews of telescopes, but am somewhat frustrated because they tend to cover sophisticated, expensive equipment. Not all amateur astronomers can afford these telescopes. Could we see more reviews covering 6-inch to 8-inch telescopes like the Meade SN8 or the Celestron SPC-6? It would make choosing a telescope easier for the budget-minded amateur. — *Jasen Rogers, East Moline, Illinois*

A Peek at the Galaxy's Core

I was thrilled by Robert Burnham's article "Strange Doings at the Milky Way's Core" (October issue). Examining the image of Sagittarius A* on page 41 was exciting — what a privileged, intimate look into the central vortex of our own Galaxy! Furthermore, there is something about the symmetry in the patterns described by the clouds of ionized gas that made me think. It seems possible that such images could be virtual images gravitationally lensed by a black hole.

I'm sure there are probably simple arguments against this, but I wonder what they might be. Congratulations on conjuring up such absorbing reading. — *Fausto Blasco, Plymouth, Massachusetts*

Radio observations show that the gas clouds all have individual motions that also are in agreement with the model described in the article. Clouds that were images formed by a gravitational lens would behave differently.

How to Combat Light Pollution

After years of frustration with offensive lights near my house I've finally discovered how to get rid of the problem. To shut off an offending light, simply remove your scope's star diagonal and eyepiece and point the telescope at the streetlight's electric eye. The sensor is a small photocell located on top of the streetlight. Place a camera flash against the scope's focuser and fire the flash. You should see the sensor bathed in a flash of light. If it is centered perfectly, the flash will fool the photocell into thinking it is daytime and shut off the light for at least several minutes. When the light turns on again, simply hit it with the flash. I have used this technique many times and it does no damage either to the streetlight or one's criminal record! — *Taras N. Wertelecki, Columbia, Missouri*

The Perils of Country Observing

What do a coyote, a four-foot snake, and an overweight skunk have to do with each other? All three of these residents of the Missouri countryside blundered through my back yard on the same night I saw mt first meteor, my first satellite, and my first lunar craters through my new telescope.

The coyote almost knocked over my tripod. I barely missed stepping on the snake. When the skunk waddled into my vicinity, I beat a hasty retreat through the back door and waited for him to move on.

That night I discovered that as exciting as terrestrial things are, they don't hold a candle to things celestial. I will be scanning the heavens at every opportunity I can grab, and your excellent magazine will be by my side at every outing. But why didn't you tell me amateur astronomy was such a dangerous hobby? — *Sandy Jones, Burfordville, Missouri*

Why Astronomers Believe

I enjoyed reading Gerrit L. Verschuur's article on what constitutes accepted theory in astronomy (Viewpoints, August 1990). In this piece Dr. Verschuur cited theoretical explanations for the erroneous observational data that indicated a strange pulsar in Supernova 1987A and odd behavior in the cosmic background radiation. "An uncomfortable feeling remains with me," said Verschuur, "that we often get so carried away by our theories that we forget that even the best of them may have little to do with reality."

It would be simple to show that at any time in history most of the theories at the forefront of science were wrong. The corollary of this is that it is the theories that have survived the longest on which most reliance can be placed.

Dr. Verschuur also stated that "the continuing challenge lies in making ever tighter the correspondence between theory and reality." Hubble's law, central to modern cosmology, can only be verified over comparatively limited distances and then only approximately. It is a fundamental assumption at larger distances. And yet even a comparatively slight deviation from Hubble's law would have far-reaching cosmological consequences.

Speculation plays a vital part in science. Are the thousand theories that fail too great a price to pay for the one that succeeds? The object of theorizing is to make predictions — as many as possible — that can then be used to test a particular idea.

Verschuur says "if theoreticians can account for virtually anything, how can we trust them?" Trust is a strange word under the circumstances. He who trusts speculation to be the truth makes a grave error, yet he who trusts well-founded speculation is often correct. — *Geoffrey M. Keyte, Hereford, England* ☐

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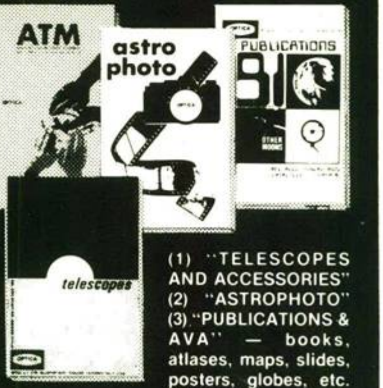

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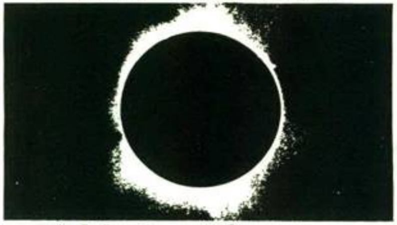

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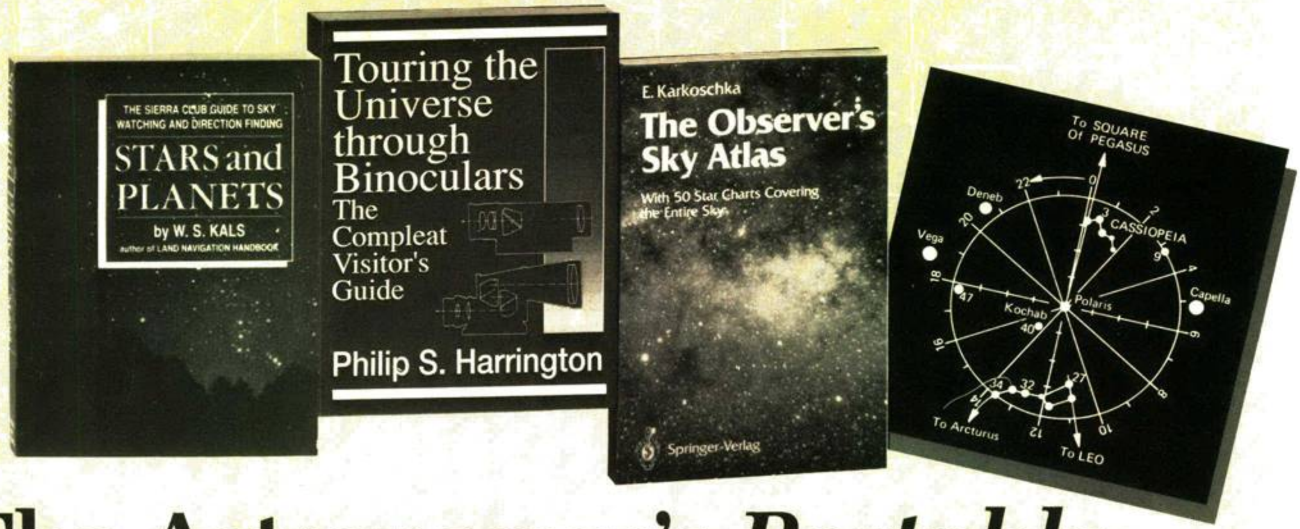
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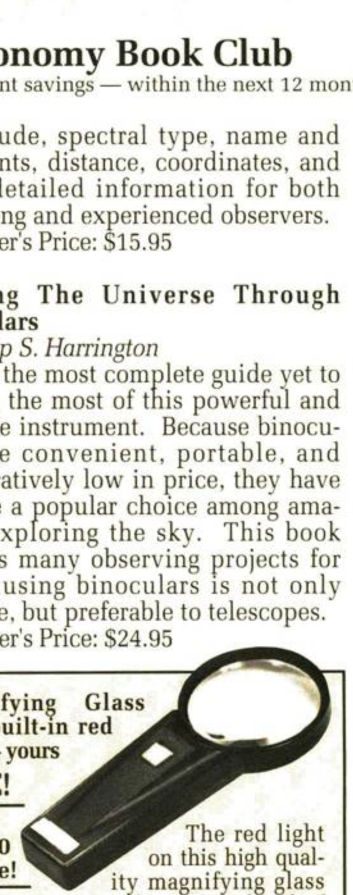

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Viewpoints

A TALE OF TWO KITTIES

by Paul H. Bock, Jr.

For some unknown reason, I have always been a cat lover. Despite being raised on a farm and spending many hours caring for a variety of livestock, I have never been very fond of dogs. I even hunted without one, which made me something of an anomaly among my teenage "good ol' boy" peers.

In later years, while serving in the Navy, my love of cats was strengthened when I read of the practice of keeping cats aboard ship in the older Navy to help keep down the rat population. If it was o.k. for the Jack Tars of a bygone era, I reasoned, then I needn't apologize for liking felines.

For the past seven years, my wife and I have given home to a somewhat neurotic calico cat; we got her as a kitten when our first cat, a lovable tortoiseshell, passed away. Callie is a declawed house cat and not much of a mouser — which is unfortunate, since we've had a minor problem with mice in the attic. Last summer, we picked up two kittens (male and female) and established permanent quarters for them in the garage. A flap door allows free access to the outdoors, and they have proven most proficient at clearing our three acres of mice, not to mention chipmunks, unwary birds, and even the occasional mole. In addition to their hunting skills, Katie and Dickie are extremely lovable, and are often underfoot whenever we're doing yard work.

Unfortunately, the same thing sometimes happens when I'm outside observing the universe.

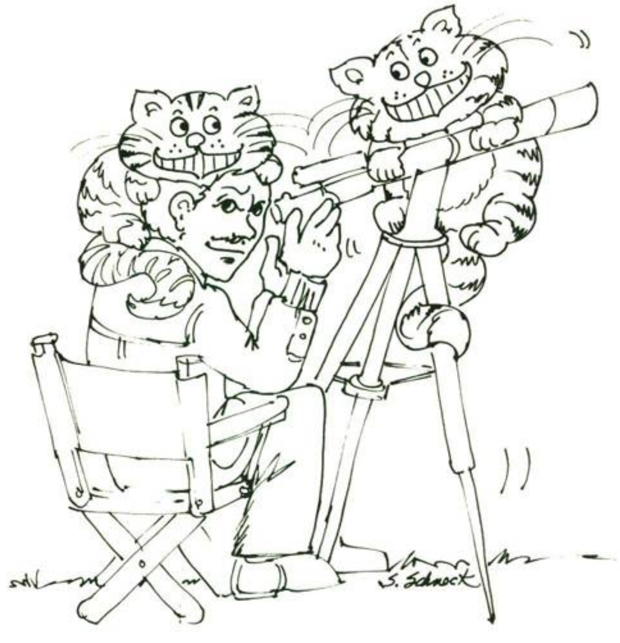
One of my favorite observing activities is timing the eclipses of Jupiter's four largest moons (Io, Europa, Ganymede, and Callisto) as they pass into and out of the giant planet's shadow. I enjoy it because the data collected is useful, it doesn't take a long time to accomplish (a blessing when the temperature is below freezing), and seeing conditions usually don't affect the results.

However, during the last minute or two before a moon disappears or just before one reappears, I am concentrating intently so as to catch and time the last or first speck right down to the nearest second. It's usually right about this time that ... well, let me paint a picture of a typical session.

Although it's 26° outside and dropping, the ephemeris tells me that Ganymede will disappear in about an hour, so an observing session is in order. Stepping into the garage, I remove the cloth cover from my tripod and mount and wrestle the entire apparatus through the door and into the backyard. Katie and Dickie suddenly appear from somewhere out of the semi-darkness, where they have no doubt been worrying a field mouse into an early grave. While I sight in on Polaris they sniff happily around the tripod, treating it as a new arrival despite the fact that they sleep right next to it every night.

With polar alignment accomplished, I return to the basement and lovingly carry up my 5" f/10 refractor, which I install on the mount and leave to stabilize its temperature while I collect the rest of my gear. Ten minutes later, after bundling up in warm clothes, collecting my notebook and eyepiece case, and setting my watch to the WWV time signals, I venture forth into the night air.

Seating myself comfortably next to the telescope, I plug in the right ascen-



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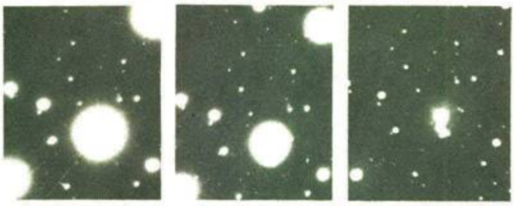

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12mm Nagler, Type II, 82°, 1¼''/2''	$249
16mm Nagler, Type II, 82°, 1¼''/2''	$289
20mm Nagler, Type II, 82°, 2'' only	$340
1¼'' Paracorr Visual Coma Corrector	$179
2'' Paracorr Visual Coma Corrector	$298

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16'' aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount .. **$54**
Specify telescope size: 6'', 8'', 10'', 11'', 14'', 16''

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$47.00	$39.00
52, 55, 58, 62mm	$59.00	$49.00
67, 72, 77mm	$69.00	$59.00
82mm	$79.00	N/A

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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LUMICON Products catalogue $2
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Prices subject to change w/o notice.
Hrs: M-F 9 am - 5 pm, Sat. 11 am - 3 pm

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3'' & 2.1'' enhanced aluminum diagonal mirrors & 1¼'' star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. 1.3-1.8'' mirrors have enhanced silver coatings (98-99%R). The extra 8-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32''	**$29.95**	1.52''	**$34.50**	1.83''	**$39.50**
2.14''	**$49.50**	2.60''	**$65.00**	3.10''	**$89.50**
4.25''	**$149.50**	4.00''	**$149.00**		

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

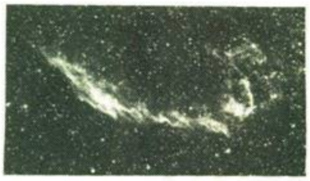
1¼'' (1.32'' mirror)	**$99.50**
2'' (1.83'' mirror)(see photo above)	**$159.00**

LUMICON FILTERS STOP LIGHT POLLUTION

UHC Filter™

ULTRA HIGH CONTRAST

The **LUMICON UHC FILTER** is specially designed for visual astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm. Transmission = 90-97%.



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a LUMICON UHC Filter. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*

Rich Zepernick, Cresskill, NJ

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter** or the **LUMICON UHC Filter**

DEEP-SKY FILTER™

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6x contrast gain for nebulae and 1-3x contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 85-95%. Visible transmission = 85-95%.

	Premium*
0.96'' **LUMICON DEEP-SKY Filter** threads into most 0.96'' eyepieces	$59.50
1¼'' **LUMICON DEEP-SKY Filter** threads into most 1¼'' eyepieces	$79.50
48mm LUMICON DEEP-SKY Filter (1.75'' aperture), threads into most 2'' eyepieces. Also fits LUMICON EASY-GUIDERS	$119.50
2'' LUMICON DEEP-SKY Filter (1.5'' aperture), threads into most 2'' eyepieces. Also has male & female camera T-threads for prime focus photography	$119.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	$299.50
1¼'' LUMICON UHC Filter threads into most 1¼'' eyepieces	$99.50
48mm LUMICON UHC Filter (1.75'' aperture) fits most 2'' eyepieces	$199.50
Set of Both premium **DEEP-SKY** and **UHC Filters** (Save 11%), Premium	$159.50
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼''** **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines .... **1¼'' $99.50, 48mm**	$199.50
Telephoto lens adapter for 2'' or 48mm filter. Select 46, 49, 52, 55, 58mm	$6.95
Universal adapter for 1¼'' filters. Adapts the 1¼'' filters to any 1¼'' eyepiece	$16.00
Universal adapter for 48mm or 2'' filters. Allows use of any 1¼'' eyepiece	$20.00

**Premium filters are selected best of the lot and typically have 5-10% higher transmission. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

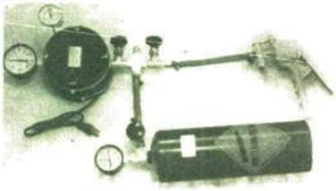
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350**

MODEL 1200 HYPER-KIT is for 4X5'' plates and film up to 5X7''. Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$295**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.

U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2'' or 1¼''.

NEWTONIAN EASY-GUIDER	**$169.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece system	**$99.50**
Guider for Hasselblad **$350**, Mamiya 645	**$199**
Adapter for Pentax 6x7 med. format	**$89**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER	**$225.00**
Adapter for Hasselblad **$185,** Mamiya 645	**$159**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10'' Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER	**$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20)	**add $99.95**
Adapter for Hasselblad **$195,** Mamiya	**$96**

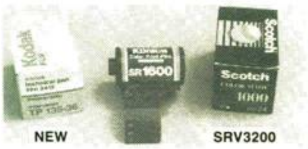
WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**

3. **LUMICON Quartz Drive Corrector** . **$219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.

Declination motor (state telescope) .. **$99**
NEW Deluxe Digital Qtz. Drive Correc. **$298**



HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	$10.95
SRV3200, fastest of all, color neg	24	$13.95
Konica SR-V3200, unhypered	24	$8.50
Konica SR400, fine grain color neg	12	$10.95
3M 1000, fastest slide film	12	$12.95
Fujichrome RD100, fine grain slide	24	$12.95
D-19 B&W Developer	1 gal.	$6.95

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IMPROVED LUMICON® SKY VECTOR II™ $589

Now 1500 of "Best" Deep-Sky Objects in Computer Memory

LOW PRICE—from $399

LUMICON SKY VECTOR FEATUREs:

- Digital right ascension readout to 1 minute of right ascension (RA)
- Digital decl. readout to 10 arc-min
- 4000 pulse (0.09° accuracy) high resolution encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial *mounts* like C-8, Meade 2080.
- **No need** to enter latitude, longitude, date, sidereal time, etc.
- 9V Battery lasts many nights.

Each LUMICON SKY VECTOR™ includes one computer with digital readout, two precision high resolution digital shaft encoders, connecting cables, & mounting hardware (for most popular telescopes). **Specify telescope.**

LUMICON SKY VECTOR™ *for* Meade 2080, Meade 2120 *(Specify)*	**$399**
For Celestron C-8, C-11 (Specify)	**$399**
For Coulter Odyssey 8", 10", 13", 17½"	**$399**
For any alt-azimuth (Dobsonian) scope	**$399**
For Celestron C-14 (rewire dec. motor)	**$498**
SKY VECTOR KIT (for skilled ATM's)	**$399**

Reference catalogues (1000's of objects)

Burnham's *Celestial Handbook*, I, II, III	**$36.85**
Revised New General Catalogue (all NGC and IC, Epoch 1975.0)	**$35.00**
Sky Catalogue 2000.0, Vol. II	**$29.95**

Only the LUMICON SKY VECTOR II has size, true visual magnitude and visual description for all 1500 objects in memory. *These features are missing from competing systems!*

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DEC
MODE
STAR
UP
DOWN
Sky Vector II™
COMPUTER SETTING CIRCLES
LUMICON ®

LUMICON SKY VECTOR II™ Computer with 1500 object memory, digital readout of coordinates, easy-to-use controls, object size, visual magnitude and visual appearance descriptions.

Please specify telescope type:

LUMICON SKY VECTOR II™ for Meade 2080, Meade 2120 *(Please specify)*	**$589**
For Celestron C-8, C-11 *(Specify)*	**$589**
For Celestron C-14 (rewire dec. motor)	**$665**
For Coulter Odyssey 8",10",13"17½"	**$589**
For any alt-azimuth (Dobsonian) scope	**$589**

The **LUMICON SKY VECTOR II™** has all the features of the regular SKY VECTOR, but has 1500 of the best deep-sky objects in memory, selected by noted observer Steve Gottlieb, along with their coordinates, size, true visual magnitude, and other descriptive data. The sophisticated computer programming also will guide you to the object selected by displaying the real-time angular separation. Just move the telescope until the angles displayed become "0" using the "GUIDE" mode.

LUMICON SKY VECTOR II FEATURES:

- Includes **size, visual magnitudes, & visual descriptions**—features missing from competing systems
- All 110 Messier objects
- Brightest 31 alignment stars
- User definable catalogue of 25 objects retained in memory without power.
- 703 galaxies, groups & clusters
- 228 best open star clusters
- *170 best planetary nebulae*
- 77 emission & reflection nebulae
- 10 best dark nebulae
- 107 best gobular star clusters
- 205 best colored & multiple stars
- ROM upgradable for planets, extended object lists, etc.
- TIMER *function, elapsed time* & stop watch
- 2 star alignment for alt-azimuth or equatorial telescope systems
- 1 star alignment if polar aligned
- Uses Epoch 2000.0 coordinates
- May align on any of the 1500 *objects in memory*

COMA CORRECTOR

Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star *images in photos. Since star images are* sharp over a full 2¼" circle, you can *use medium format cameras in addition* to 35mm cameras. This zero power lens *does not change image scale nor shift* focus, and all lens surfaces are multi-*coated for highest efficiency.* Although designed for photography you may also *use this lens to improve image quality* in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER	**$169.50**
2" EASY-GUIDER (Mamiya 645)	**$199.50**
2" Adapter for Pentax 6x7	**$85.00**
2" Adapter for Hasselblad	**$185.00**
2" Adapter for Bronica SQ-A	**$175.00**
2" Extension for viewing	**$26.00**

MEADE® TELESCOPES

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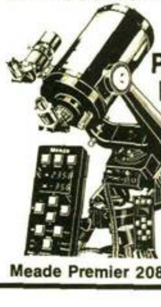
NEW PREMIER SERIES TELESCOPES

All Meade Premier Series telescopes **include Smart Drive (SD) permanent periodic error correction,** multi-coated enhanced optics (MCOG) and **include** advanced LX6 all-electronic drive system. **Select f/10 or f/6 optics, and select only the** optional features you **need.** The 8" has an 6X30 finderscope and the 10" has an 8X50 finderscope. SD = Smart Drive, SP = *Special Promotion.*

2080 Model 30SD, 8" f/10	**$1495**
2080 Model 36SD, 8" f/6	**$1695**
2120 Model 30SD, 10" f/10	**$1895**
2120 Model 30SP, *10" f/10*	**$1599**
2120 Model 36SP, 10" f/6	**$1699**
Model 2600 16" f/10	**$9950**
LX6 Smart Drive upgrade	**$299**

Options Enhance Performance

Super Wedge for 10"	**Add $240**
ECC Electronic Command Center	**$275**
#39 Declination motor	**Add $109**
Digital setting circle	**Add $399**
2" Star diagonal	**Add $179**
LUMICON Cassegrain Easy-Guider *(Please specify camera)*	**Add $225**
LUMICON Giant Easy-Guider (for #30) *(Specify camera)*	**Add $395**
LUMICON Giant Easy-Guider (for #36) *(Specify camera)*	**Add $295**



PREMIER 2080
MODEL 50SD
$1795

Meade Premier 2080 Model 50SD

MEADE SERIES 4000 EYEPIECES

Super Plossl: 6.4mm, 9.7mm, 12.4mm **$89** 15mm, 20mm, 26mm **$89; 32mm $109**
Super Wide-angle: 13.8mm **$129,** 18mm **$135,** 24.5mm **$149,** 32mm (2") **$219**
Ultra Wide-angle: 4.7mm **$149,** 6.7mm **$179,** 8.8mm **$209,** 14mm **$249**

SCHMIDT-CASSEGRAIN

2045D 4" f/10 w/motor drive	**$695**
2080A Standard 8" f/10 w/tripod	**$999**
2080B Std. w/tripod, MCOG	**$1058**
2080 Model 50SD, 8" f/10	**$1795**
2120 Model 50SD, 10" f/10	**$2295**
2120 Model 50SDH, 10" f/10 w/Super Wedge, Smart Drive	**$2535**
2080 Model 56SD, 8" f/6.3	**$1995**
2120 Model 56SD, 10" f/6.3	**$2495**
2120 Model 56SDH, 10" f/6.3 w/Super Wedge, Smart Drive	**$2735**
Dew shield - essential! 8" **$65;** 10"	**$98**
LUMICON EASY-GUIDER for 2080	**$225**
EASY-GUIDER (f/4-f/10) for 2120	**$395**
CAT command control, 8200 objects	**$999**

SCHMIDT-NEWTONIAN

MTS-SN6, *6" f/5, #788 drive*	**$649**
MTS-SN6 w/drive, MCOG	**$698**
MTS-SN8, 8" f/4 w/drive, MCOG	**$795**
MTS-SN8, 8" f/4 w/LX3 drive, MCOG	**$1048**
#36 LX3 hand cntrl. & #38 dec. motor	**$189**

NEWTONIAN

Model 826C 8" f/6 w/motor, 2" focuser	**$898**
SPECIAL PROMOTION	
Model DS-10A, 10" f/4.5 with motor, 2" focuser	**$775**
Model DS-16AB, 16" f/4.5 w/motor, 2" focuser, Sealmaster ball bearings	**$1875**
8X50mm finderscope w/brackets for DS-10 or DS-16	**$109**

1.8x MULTIPLIER LENS

1.8x Multiplier Lens

The computer-designed LUMICON 2" Multiplier/Field Flattener multiplies the image scale in photography by 1.8x (f/4.5 becomes f/8). Use it with any LUMICON 2" EASY-GUIDER. Guide-stars also become much sharper to make guiding easier. This lens is optimized for f/4.5, but will work well with any optical system. *It may also be used visually as* a highly corrected 2" Barlow lens.

LUMICON 1.8x *multiplier lens*	**$235.00**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM $49.50

LUMICON® LOW PROFILE FOCUSERS

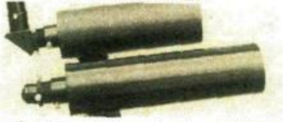
LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	**$49.50**
LUMICON 2" Helical Focuser 1½" high	**$59.50**
LUMICON Non-rotating Helical Focuser	**$89.50**
2" rack & pinion focuser, only 2" high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2"/1¼" adapter *w/48mm filter threads*	**$20.00**
2" LUMICON EASY-GUIDER	**$169.50**

LUMICON ACCESSORIES

LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, *including most* Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra. The

1¼" 50mm Finderscope **$59.50**, right-angle	**$89.50**
1¼" straight-thru 80mm SUPER-FINDER	**$169**
1¼" right-angle 80mm SUPER-FINDER*	**$179.50**
1¼" right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼" eyepiece (12X)	**$29**
*1¼" Star Diagonal **$32**, 2" Star Diagonal,	**$159**
1¼" Amici Prism diag. for correct left-right views	**$69.50**

2" ADAPTERS MEADE, CELESTRON TELESCOPES

These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

2" adapter for C-8, Meade 2080, etc.	**$26.00**
2" adapter for C-80, C-100 refractor	**$39.50**
2" *adapter for C-70, C-80F, C-90F, C-100F*	**$39.50**
2" Accessory adapter for Comet Catcher*, C-6*, Meade 310, 320 refractor	**$30.00**
2" adapter for Takahashi E-130, 160	**$59.50**

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* Subject to Availability

sion drive controller and battery pack, check my notes, and tuck the appropriate eyepieces into my inside coat pocket. Katie and Dickie pay another courtesy call, rubbing against my leg briefly before dashing off into the blackness. (Fortunately, there's one thing I'm sure they're not doing, thanks to the local vet.)

After uncovering the objective and installing the dew cap, I remove the finder covers, slip an eyepiece into the focuser, and check out a few objects. I swing over to Jupiter and notice a slight green flare at the bottom of the image, which tells me that there is still a little warm air near the top of the tube. Experience tells me it will be gone in a few minutes, so I observe a few double stars and then begin examining Jupiter's surface for anything worth making note of, drawing, or timing as it crosses the central meridian. There is no sign of the two cats.

It is now coming up on the time for Ganymede to disappear. Mumbling under my breath, I try to position my watch and my half-moon reading glasses so I can quickly shift back and forth from the eyepiece to the watch, catching that precise instant when the little Galilean satellite is no longer visible. My gaze alternates between the slowly dimming speck of light and my watch as I repeat the time aloud: "Thirty-two and fifteen seconds, still visible... Still visible... Forty-five seconds.... "

I am suddenly aware of a pulsing, humming noise. My brain is screaming "Oh, no, not the drive!" when a fur-covered head rubs against my chin and bumps the focuser, causing Jupiter to jump violently from side to side. Dickie is purring as if I've just offered him a hot meal, and rubbing against my leg tells me his sister shares his affection for me.

"Not now, Dickie!" I snarl, to no avail. My gloved hand pushes him aside while I try to recapture that fleeting, fading sliver of moon, but he will not be denied. He begins to crawl up the side of my coat while his sister playfully bats the now-dangling drive controller.

"Why do you do this to me every time?" I plead, as the sound of two feline motors blends asynchronously with the clicking of the drive.

Finally, in the nick of time, I manage to put the controller out of reach and hold Dickie stationary with my left hand. Katie edges away, glaring at me suspiciously, as I again check the time. Looking through the eyepiece, I breathe a sigh of relief at the sight of a tiny, still visible remnant of Ganymede. In less than a minute, the speck disappears from view and I triumphantly call out the time from my watch. I release Dickie, and as I pick up my notebook to write down the results the two cats amble disinterestedly across the yard and enter the garage through their flap door. The rest of the observing session, and the subsequent disassembly and storage of the equipment, is accomplished in total solitude.

It seems certain to me that I have stumbled upon one of the lesser-known reasons why the observatory was invented. I'll bet William Herschel and his sister, Caroline, — who observed with telescopes out in the open — were cat lovers.

IF YOU LIKE ASTRONOMY, SAY SO IN PRINT!

by Mike Lynch

Have you ever wanted to tell people about the things they can see on a clear night? Alert them to an upcoming eclipse or meteor shower? There's no better time than now.

After reading headlines about the "trouble with Hubble" and NASA's problems getting Space Shuttles off the ground, it strikes me that the American public may be slipping into a cynicism about science in general and perhaps wondering if astronomy in particular is populated by bumbling nerds.

Those of us who pursue astronomy out of sheer interest can help set the record straight and prevent the public's perception of this fascinating science from being permanently warped.

I'm not suggesting that we help rescue NASA's public image. Instead, I'm arguing that we need to help the public separate astronomy from the space program in their minds, and to learn that the average backyard with little or no investment can be their window into a wondrous universe.

Moreover, to convey that message we should consider using the same medium which has been the vehicle for much of the recent bad space news — the press itself. I suggest that there's no better time than now for people to write an astronomy column for their local newspapers.

Of course, there are several basic (even obvious!) questions a potential astronomy columnist should ask before setting out to interest a newspaper. Do you like to write? Do you really believe you

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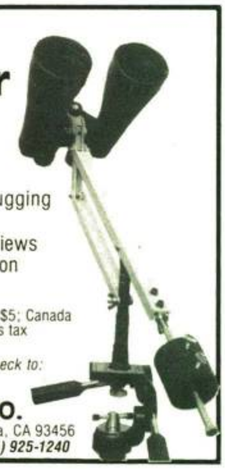

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can express yourself well in print? Does the newspaper you want to approach have a science page or section appropriate for such a column? (Don't be shy of suggesting the "Lifestyle" section. I've always believed an editor's attention can be caught by a gutsy or creative suggestion for a piece, accompanied by compelling reasons for printing it.)

Most important — if you really want to write about this fascinating subject, don't give up trying when you're turned down. (It will happen.) Write to more newspapers in your region, and write back to editors who've rejected your idea once an appropriate amount of time has passed or another good reason develops, like a new comet is found.

I began hunting for a newspaper to print a weekly or monthly astronomy article shortly after Halley's Comet departed the scene. I wrote several sample articles about typical items of interest in the night sky, telling editors there is so much more overhead than occasional bright comets. I also argued that such a column could do their readers a service and perhaps get some additional readership. Like any other business person, editors need to be convinced they will get something out of adding a column.

One small daily in central Kentucky responded enthusiastically to my suggestion and kept promising to "get back" to me when the editor was ready for a submission. I may be patient, but I'm not completely stupid. Within a few weeks, I wrote also to a major newspaper in the state. The science-page editor called my idea "intriguing" but concluded there was not enough space for a new column and urged me to write back in about six months.

Though encouraged, I wasn't patient enough to wait that long for something that might never materialize. I tried a third newspaper, the Lexington Herald-Leader. The editor wrote back that he was referring my proposal on to a managing editor, who would soon contact me. After exactly one month, I resubmitted my entire original proposal to the managing editor with a cover letter asking, in effect, "Why haven't I heard from you?"

A reply quickly followed. I opened the envelope, anticipating another rejection. I had to read it twice to believe the unexpected — the proposal was accepted, a payment rate was offered, and I would be printed the last Thursday of each month on the science page. Extra columns would be considered for astronomy events worth writing about.

Since December 1988, I have told readers about meteor showers, the movement of the planets, seeing the Milky Way and how (or whether) to buy a telescope. I have suffered the embarrassment of heralding Comet Austin a bit too enthusiastically, and enjoyed the brief outburst of auroral activity visible even in Kentucky just two months after I urged readers to be ready for one.

Science page editor Mary Ann Stanley encourages me to submit sky maps with explanations. Her graphics artists do the final rendition on computer. To add credibility I have occasionally quoted sources, including ASTRONOMY, which gave me permission to republish a graphic with a credit line for the magazine.

Perhaps because I love to write, I work hard to reduce what might otherwise be complex scientific concepts about astronomy to understandable language, urging the reader to look up and see the things I enjoy myself. In fact, most of my columns deal with items visible to the naked eye or with a pair of binoculars.

I cannot claim to receive a constant stream of mail from readers. That just doesn't happen. But people do read the articles and occasionally comment or contact me with a question. I've also received some extra requests to speak to classes and even to teach an evening class for a community education project.

The column has, I hope, alerted the general public to events they might not otherwise notice, dispelled some misconceptions about things astronomical, and contributed to a sense of wonder at the universe which is so visible to most of them on a clear day or night.

In perhaps only a small way, that contribution helps prevent people from equating astronomy with the space program or from seeing this science as something distant and detached from their lives.

Very few readers will ever look through a telescope the size many amateur astronomers build or own; fewer still will take the interest to get involved in serious observation. But I want to get my readers to see the sky a bit better and to view astronomy their own way, not just through NASA photos.

It took some patience to start the column and still occasionally requires some motivation to keep going, even for a once-a-month deadline. But I think I, too, get more out of my hobby now.

Anyone else up for the challenge — and the rewards? □

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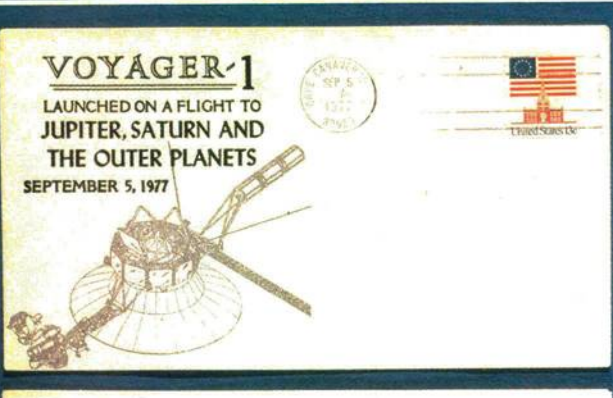
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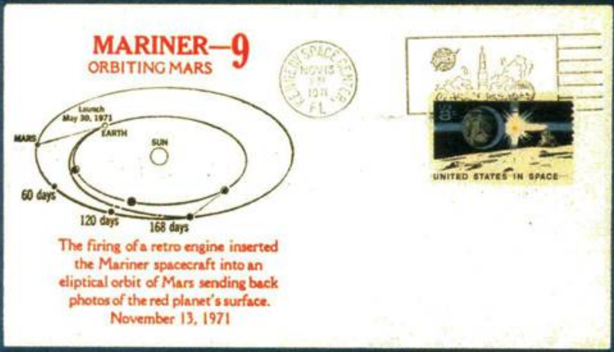
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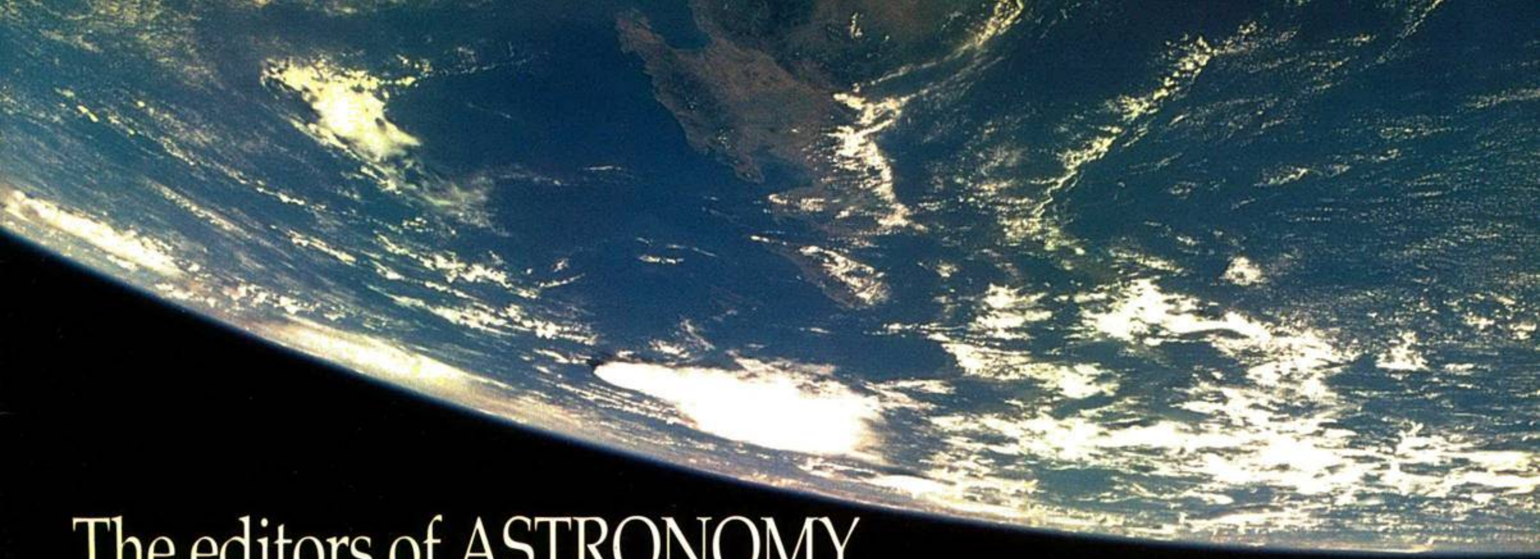

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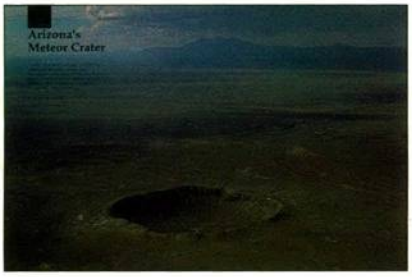
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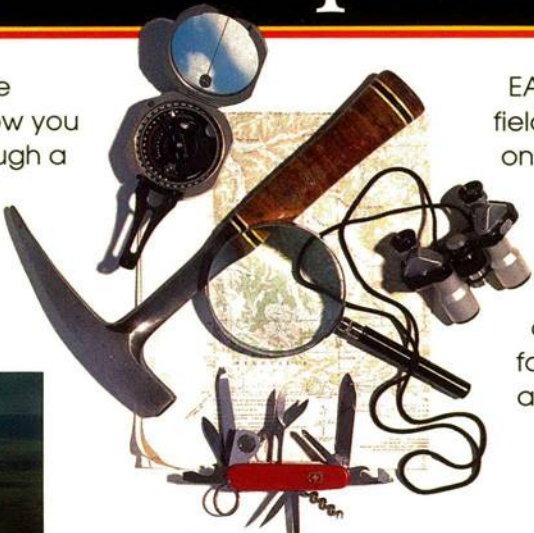

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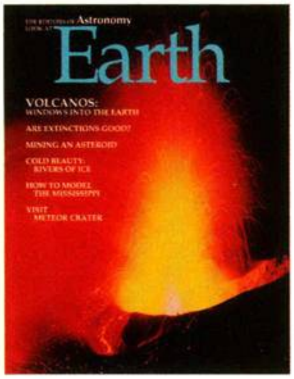
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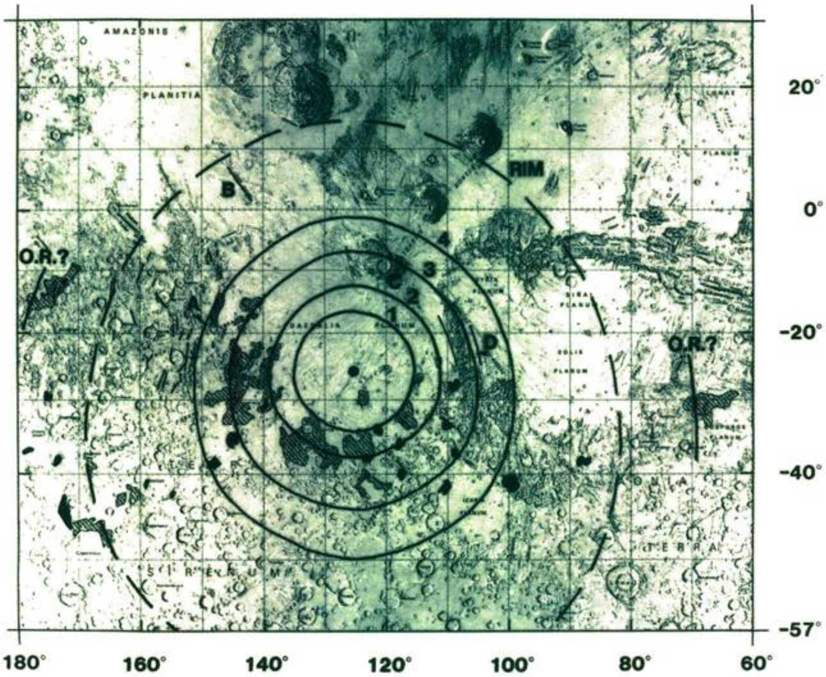
IS DAEDALIA PLANUM AN ANCIENT MARTIAN IMPACT BASIN?

Daedalia Planum, a relatively flat expanse on Mars that lies to the southeast of Olympus Mons at 26° south latitude and 125° longitude, is an ancient impact basin, according to planetary scientists Robert Craddock of the National Air and Space Museum and Ronald Greeley and Philip Christensen of Arizona State University. If they are right, it is the largest multi-ring basin found on Mars.

Writing in the July 10, 1990, issue of the *Journal of Geophysical Research*, Craddock, Greeley, and Christensen note that grooved features exist in the highland terrain surrounding Daedalia Planum. Running generally radial to the center of Daedalia, these features closely resemble the grooves found in the highlands around the Imbrium basin on the Moon. These latter features appear to have been caused by debris flying from the Imbrium impact and by movement along faults that lie radial to the lunar basin.

Another telltale feature pointing to an impact origin for Daedalia are five concentric rings of uplifted terrain with spacing ratios similar to those seen in impact basins on the other terrestrial planets. The putative basin's diameter is about 4,500 kilometers. Careful study of the geologic features affected by the basin indicate that in the scheme of Martian stratigraphy it probably dates from the early Noachian epoch, thought to have occurred during the first billion years of Mars' history. This makes it one of the oldest surviving basins on the planet.

The scientists also see links with later volcanism. For example, Arsia Mons (the southernmost of the Tharsis volcanos) lies astride the third of the basin's rings. The scientists figure that the shock of the impact which excavated the basin would have faulted the crust deeply, allowing lava to spill out and flood the basin itself. Later, these same faults might also have provided an easy route to the surface for lavas erupted in the Tharsis period of volcanism. Faulting could also play a role in the floods that carved the channels of Mangala Valles, which adjoin Daedalia Planum on the west, by providing a pathway to the surface for underground water and other volatiles.



BROAD, SMOOTH, AND ROUND, Daedalia Planum may be Mars' largest surviving impact basin — and one of its oldest. Five concentric rings are shown together with a possible outer ring (marked O.R.). Dark patches show volcano fields, and striped patches show early Noachian highlands. The source region for the Mangala Valles floods is shown by A, while B marks grooves in Gordii Dorsum, C is Arsia Mons, and D is faults in Thaumasia and Claritas Fossae.

ARE SPORADIC METEORS TRULY RANDOM?

On any clear night, about five meteors an hour can be seen zipping briefly across the sky. These so-called sporadic meteors appear at random and don't belong to any known meteor shower. However, a British researcher now feels that some of these maverick meteors may not be so random after all. David Hughes of Sheffield University suggests that the major meteor showers come from the breakup of only the most massive comets, ones that are relatively rare. More common low-mass comets should also produce streams of dusty meteors, but of much lower density. When Earth collides with these streams the frequency of meteors seen in the sky could be so low that it would be difficult for observers to tell there is a shower going on.

Writing in the July 15 issue of the *Monthly Notices of the Royal Astronomical Society*, Hughes suggests that twenty percent of the meteors thought to be sporadic are actually the "drizzle"

The multinational orbiting x-ray observatory ROSAT made this image of the First Quarter Moon with a 1,000-second exposure. It shows the sunlit half of the Moon (right side) emiting x-rays as its surface fluoresces under the impact of solar x-rays. The dark half of the lunar disk meanwhile blocks the x-ray background. Max-Planck-Institut photo.

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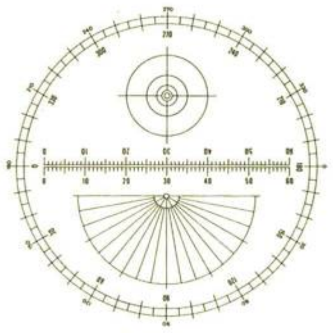

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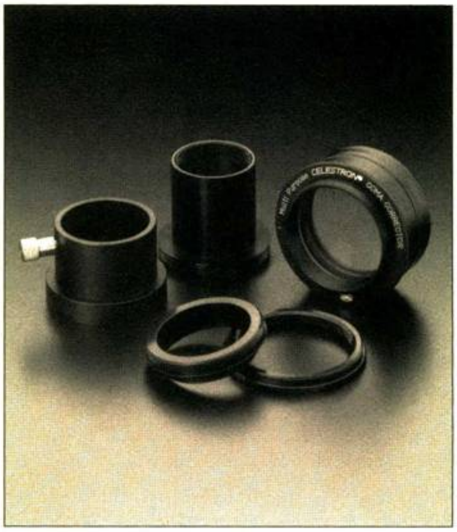

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of very light showers. According to his calculations there could be as many as 70 showers producing between one and nine meteors an hour at their peak, compared to the 20 or so light showers that are known now.

Space News

ULYSSES OFF TO THE SUN

On October 6 the *Ulysses* space probe became the fastest human-made object ever propelled into space. The five-year mission of *Ulysses* includes a flyby of Jupiter followed by passages over the south and north poles of the Sun. As with most space science missions launched recently, the *Ulysses* mission had been long-awaited. A joint project of the European Space Agency and NASA's Jet Propulsion Laboratory, *Ulysses* was to have been launched in 1986, but was postponed until 1990 due to delays in the shuttle program. Recent problems with the shuttles *Columbia* and *Atlantis* that kept them grounded through the summer threatened the critical launch date for *Ulysses*. The probe had to get on its way by October 23 or face another 13-month delay on the ground waiting for Jupiter to return to a proper position in the sky. The Jupiter alignment was critical since *Ulysses* will use Jupiter's gravity to sling the probe down out of the plane of the solar system for a passage under the south pole of the Sun. Fortunately, the shuttle *Discovery* did not share the technical problems of its two sister ships, and the launch on October 6 was described by NASA officials as "letter-perfect."

ULYSSES FLOATS FREE after being released from *Discovery* on October 6 and just prior to the firing of the booster stages that propelled the craft toward Jupiter. NASA photo.

After being placed into low-Earth orbit by the shuttle, *Ulysses* fired its own rocket motors to propel it toward Jupiter. A boost from a two-stage Inertial Upper Stage (of the type used previously on the *Magellan* and *Galileo* probes) was followed by an additional kick by a PAM-S Payload Assist Module (similar to rockets used to boost communications satellites into geosynchronous orbit). The combined thrust of the stages rocketed *Ulysses* away from Earth at a velocity of 34,130 miles per hour. At that record-breaking speed *Ulysses* passed the Moon's orbit after only seven hours. *Ulysses* will reach Jupiter in February 1992, almost four years ahead of *Galileo*. However, *Ulysses* won't linger at Jupiter, nor will it take photos since *Ulysses* does not have a camera system — its experiments consist of detectors for measuring solar wind, magnetic fields, charged particles, solar x-ray and gamma rays, and interplanetary dust.

When *Ulysses* passes 260,000 miles from Jupiter's cloudtops on February 8, 1992, the planet's gravity will fling *Ulysses* into uncharted territory, the region of the solar system below the plane of the planets' orbits. The probe will reach 80° south solar latitude in June 1994 and begin its flight under the Sun's south polar region, passing a safe 2 AUs from the surface of the Sun. *Ulysses* will then venture north, crossing the Sun's equator in February 1995, followed by a four-month pass over the Sun's north polar region beginning in June 1995. The *Ulysses* mission is scheduled to end in September 1995, just as *Galileo's* final approach to Jupiter is beginning. You can find more information about *Ulysses* in "Seeing the Unseen Sun" in the January 1990 ASTRONOMY.

COBE LOSES ITS COOL

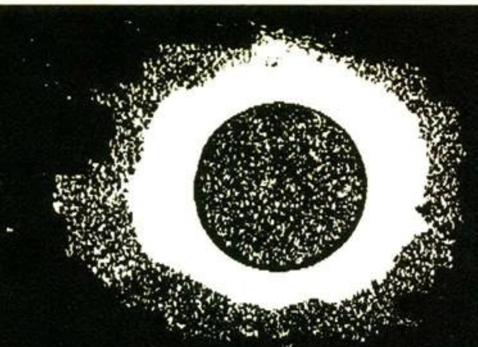
On September 21, 1990, the *Cosmic Background Explorer* ran out of super-cold liquid helium. The liquid helium was used to cool two of *COBE's* detectors, the Far Infrared Absolute Spectrometer (FIRAS) and the Diffuse Infrared Background Experiment (DIRBE), to less than 2° above absolute zero. However, scientists aren't worried. The depletion of the helium was expected to occur at that time and the two experiments had produced results to more than satisfy astronomers.

Since launch on November 18, 1989, *COBE* has mapped the sky in the infrared wavelengths searching for variations in the cool remnant radiation from the Big Bang. Both the FIRAS and DIRBE experiments produced textbook results, confirming the Big Bang theory. (See "Too Smooth — COBE's Perfect Universe," June 1990 ASTRONOMY.) With the cooling helium gone, the lifetime of FIRAS is over. However, a warmed-up DIRBE can continue to measure the sky's background radiation in the near-infrared bands. A third experiment, the Differential Microwave Radiometer (DMR), is unaffected by the loss of cooling; it will continue remapping the sky to increase the sensitivity of its earlier all-sky surveys. These maps could reveal the faint infrared glow from the first objects to form in the universe.

MAGELLAN GLITCH IDENTIFIED

As we go to press, technicians at NASA's Jet Propulsion Laboratory were preparing to resume *Magellan's* radar mapping of Venus, only two weeks behind schedule. During early September, *Magellan* was placed in a safe mode while the spacecraft slowly read out its vital engineering data. After analyzing this information, JPL technicians are confident they've identified the source of the computer problems that sent *Magellan* into gyrations shortly after entering Venus orbit. While suspicions first fell on spurious charges from cosmic ray hits or radiation damage, the culprit now appears to be electrical noise from wires that were sliced as the solid rocket motor separated from *Magellan* after orbit insertion.

With the problem identified, JPL staff have been able to re-program *Magellan* with new safety routines that should prevent any more catastrophic losses of signal. Scientists poring over the detailed radar images of Venus are now anticipating a normal mission and an exciting few months of continuous discoveries.



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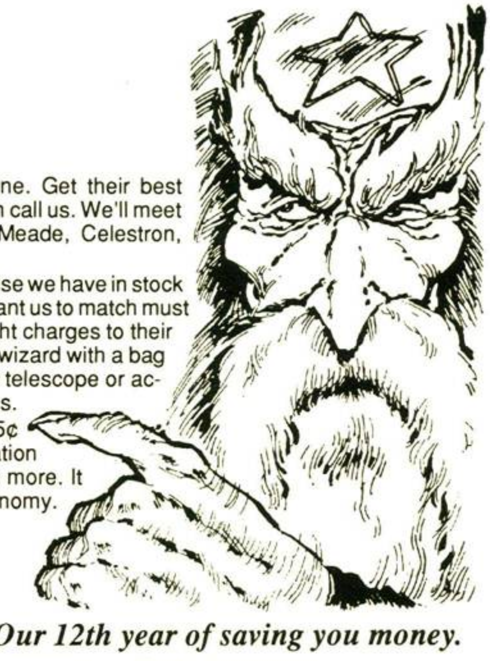

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VARIABLE STAR OBSERVING GOES WORLDWIDE

"More than ever, amateur astronomers are making important contributions to astronomy research by observing variable stars." This conclusion was firmly established at the first European meeting of the American Association of Variable Star Observers (AAVSO), held in Brussels, Belgium, on July 24-28, 1990. The meeting was attended by a nearly equal mixture of amateurs and professionals from thirty countries, including a large contingent from eastern Europe.

Some thirty-five presentations demonstrated the many ways in which amateurs' observations are being used at the frontiers of variable star research. These observations have been especially useful for monitoring the behavior of cataclysmic variables during spacecraft observations of these stars. Amateurs are also monitoring several hundred Mira variables to predict their brightness while they are being measured by the European astrometric satellite Hipparcos.

The meeting was highlighted by a report from AAVSO Director Janet Mattei on AAVSO activities. Mattei demonstrated the increasing demand by professionals for amateurs' observations, and the variety of ways in which they are used. She also conveyed the enthusiasm, dedication and skill of amateur variable star observers worldwide.

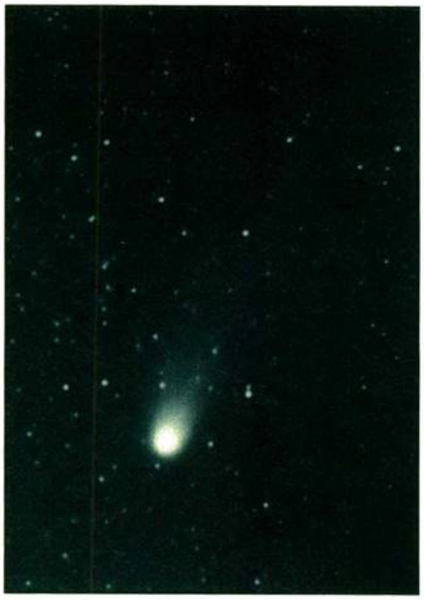
Informal discussions formed an important part of the meeting. Many of these took place in a reception hall containing the poster papers and an extensive and spectacular exhibit of the work of the European Southern Observatory. Participants will certainly remember the fine Belgian beers that fueled the discussions, the cosmopolitan nature of Brussels, and the warm hospitality of the hosts from the University of Brussels and the Vereniging Voor Sterrenkunde — the local amateur astronomy society.

In summarizing the meeting, AAVSO President John Percy asked how international cooperation and coordination in variable star observing can best be expanded in the future. One possibility is through an international working group consisting of amateur and professional astronomers with a strong interest and involvement in the field.

Members feel the Brussels meeting will be remembered as the first of a series in which amateur and professional astronomers from around the world came together to advance the cause of astronomy. — *John R. Percy.*

LEVY CAPTURES LEVY

"Of all the photos I took of the comet, this one's my favorite," exclaimed a proud David Levy. The discoverer of 1990's brightest comet managed to capture one final image of his namesake visitor on September 14, 1990, before the comet dropped from view from northern latitudes. At the time of the exposure, Comet Levy was only 7° above the southwest horizon. "It had been cloudy for several days," explained Levy, "but on the evening of the 14th I watched as a small hole opened in the clouds in just the right spot. I quickly aimed my Schmidt camera and was able to take one 2-minute photo before the comet disappeared behind the trees. It was a lucky break — a few minutes later it started raining." The photo involved more than careful timing. As Levy told ASTRONOMY, "Because of the awkward angle of the camera, to look into the guiding eyepiece during the exposure I had to stand on a chair and lean over the wall of my roll-off roof observatory!" The hard-won photo was the only one Levy was able to take of his comet using his 8-inch Schmidt camera, a system he set up in 1990 to do photographic searches for new comets. When Comet Levy was at its brightest in August 1990, Levy was on duty as an observer at Palomar Observatory. He obtained a number of images using Palomar's 18-inch Schmidt Camera. "I'm very proud of those shots," said Levy, "but the lone photo with my own Schmidt camera is kind of special. It's the one I'll remember 1990c by."



WESTERN AMATEUR ASTRONOMERS AWARDS ANNOUNCED

The Western Amateur Astronomers, one of the largest federations of astronomical societies in the world, has announced its 1990 awards honoring achievements in amateur astronomy. The group's top award, the G. Bruce Blair medal, was presented to well-known comet hunter David H. Levy, who has given a "lifetime of dedicated work in popularizing astronomy, especially among young children, and has achieved notoriety for his comet discoveries, now numbering six."

The WAA presented Caroline Herschel Project awards to Stephen James O'Meara for his work in exceptional visual sensitivity observing projects; Ronald E. Royer for tricolor astrophotography projects; and Donald Parker for high-resolution photography of the planets. E. E. Barnard observing awards were given to John Bortle for scientifically useful comet observations and to Charles Scovil for his observations of variable stars.

The newly created Clyde Tombaugh award was presented to none other than Clyde Tombaugh for his design and fabrication of a 5-inch Richest Field Telescope. In future years the award will be presented to an amateur or professional astronomer who "creates, designs, and fabricates an innovation that improves the use and performance of the telescope for the benefit of the astronomical community." □

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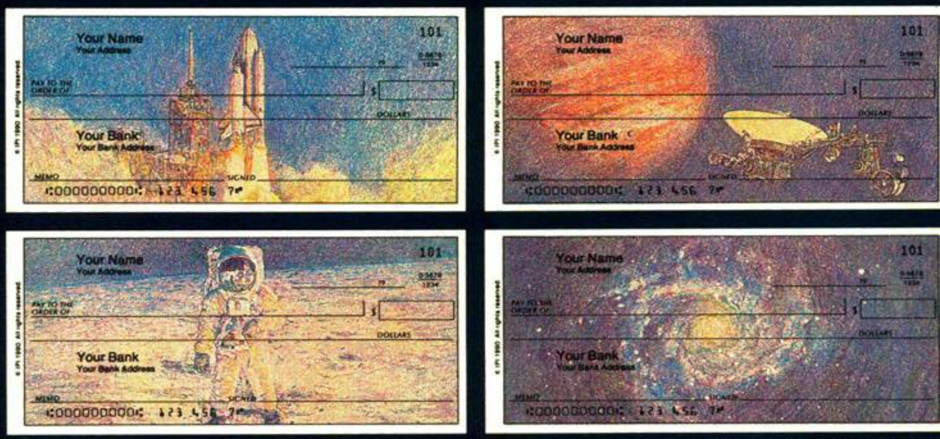

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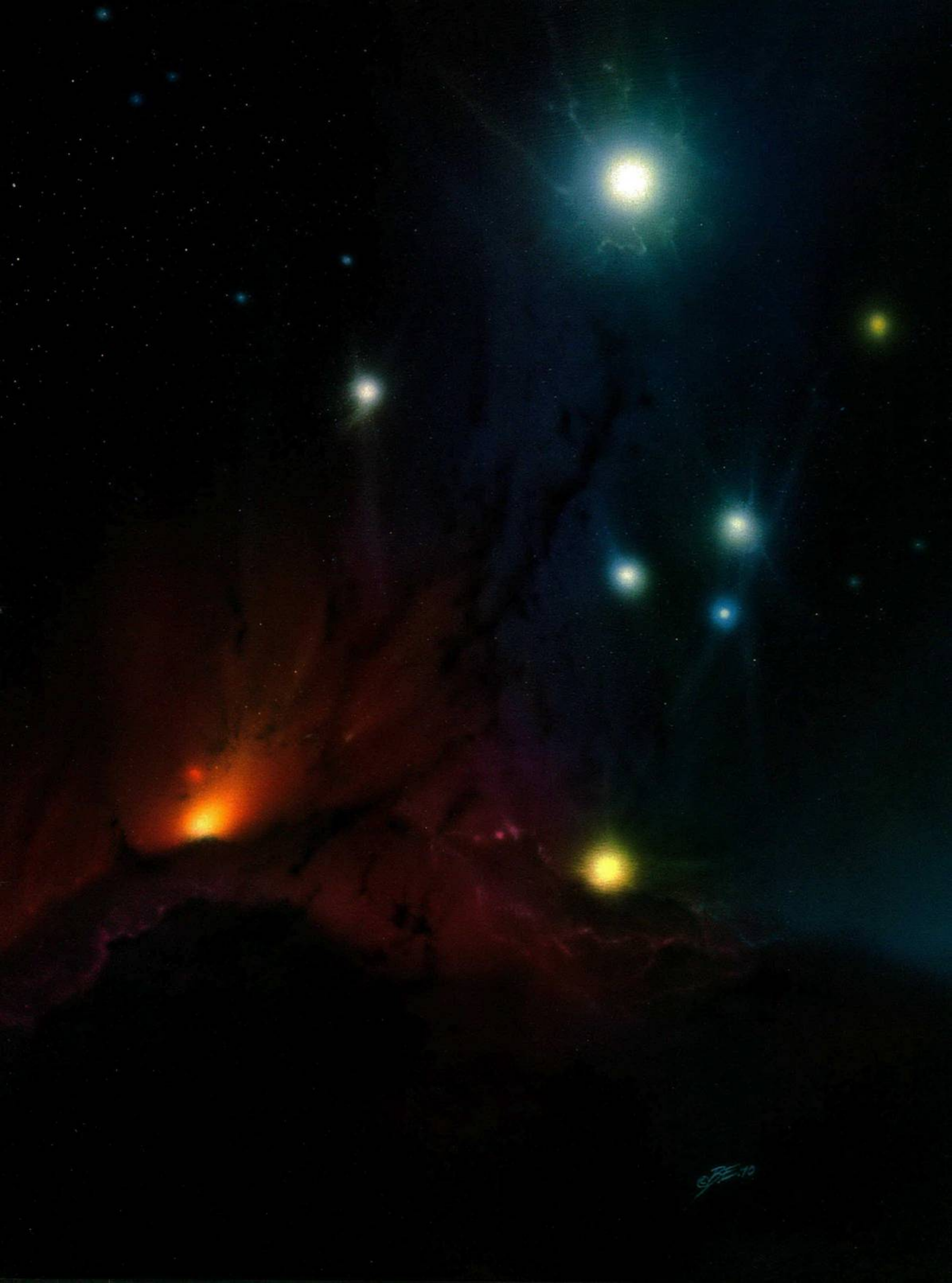
ASTROPHYSICAL FRONTIERS

A Star That Breaks All the Rules

A nearby, fast-spinning red dwarf star named Gliese 890 has astronomers puzzling over its mysterious origin and erratic behavior.

by Ken Croswell



Faint, cool, and small, most red dwarf stars lead quiet lives of little renown. Recently, however, a nearby red dwarf named Gliese 890 has intrigued and puzzled astronomers. They have discovered the star is spinning extremely fast — dozens of times faster than the Sun.

So what's the big fuss about a fast-rotating star? According to theory Gliese 890 should rotate very slowly, like other stars of its type — but it doesn't. And the more astronomers have looked at this star, the more oddities they have uncovered. Tracking down the behavior and origin of Gliese 890 has progressed from a few observations of an ordinary star to a full-blown astronomical mystery. How can a star with such an ordinary appearance and place in the Galaxy violate the rules that govern how stars behave? Astronomers set out to discover the answer.

Like the Sun, and unlike Gliese 890, most single late-type stars rotate slowly. They are cool yellow, orange and red stars of spectral types G, K, and M. (In contrast, many early-type stars — hot blue and white stars with spectral types of O, B, and A — spin fast.) A late-type star spins slowly because it has a magnetic field that carries gas away from the star's surface. As it loses more and more material, the star turns more and more slowly, just as a spinning ice skater spins more slowly when he extends his arms. Astronomers call this spin-down process magnetic braking, and it is responsible for the slow rotation of single, late-type stars.

Such is not true, however, for late-type stars in binary systems. In this case late-type stars can continue to spin fast, because they convert the spin energy of their orbits into rotational energy, thus counteracting magnetic braking. Each star in such a binary raises tides on the other, and the two stars get locked together.

But the binary star case cannot explain Gliese 890. This star is solitary and it rotates in less than half a day — a far cry from the Sun's rotation period of a month. The star's rapid rotation produces some curious by-products that fascinate astronomers who observe Gliese 890. These include starspots and stellar flares that cause the star's brightness to vary. The erratic behavior of this star has also started astronomers thinking about the star's origin.

"Gliese 890 is a rapid rotation laboratory for late-type stars," says Arthur Young of San Diego State University, who has studied Gliese 890's starspots. "But why is it rotating so rapidly? When these things are in binaries, that's not an issue — they have no choice but to rotate rapidly. But when they're single like this, then our thinking is that this is a signature of youth. But if the star is very young, then what's it doing in the solar neighborhood?"

Out of Obscurity

The recent interest in Gliese 890 marks a sharp departure from years of neglect. American astronomer Alexander Vyssotsky announced the star's discovery in 1952, but he buried it in a list of over a hundred other K and M dwarfs. Gliese 890 glows faintly at magnitude 11 and lies in eastern Aquarius. In 1957 German astronomer Wilhelm Gliese published his first *Catalogue of Nearby Stars,* which contained 915 stars within 65 light-years of the Sun. At a distance of approximately 65 light-years, star number 890 barely made it into Gliese's catalog.

There, for two decades, Gliese 890 sat. It was just another red dwarf in a Galaxy full of them. Red dwarfs are fainter and cooler than the Sun because they have less mass, but they outnumber all other types of stars put together: 70 percent of the stars in the Galaxy are red dwarfs.

In the late 1970s Arthur Young and his colleagues took spectra of 72 nearby red dwarfs, most drawn from Gliese's catalogue. Spectra can determine how fast a star turns, because rotation broadens the lines in spectra. One limb of a spinning star recedes from us and is redshifted, while the other limb approaches us and is blueshifted. The net result is that rotation causes every spectral line to appear smeared out. The faster the rotation, the broader the lines. By measuring the breadth of the lines, an astronomer can determine a star's rotation speed.

Gliese 890 has broad spectral lines and so is spinning extremely fast for a single, late-type star. The Sun rotates at just two kilometers per second, and most single red dwarfs in the solar neighborhood spin at less than five kilometers per second. Moreover, all single red dwarfs in the solar neighborhood rotate at less than 25 kilometers per second — except for Gliese 890. Gliese 890 is spinning at the extraordinary speed of 70 kilometers per second.

"We could not believe that an M dwarf star could rotate that rapidly and be single," says Young, who for many years assumed the star must be part of a binary system.

But Gliese 890 proved to be single: its line-of-sight velocity did not

Did Gliese 890 Escape the Pleiades?

Astronomer Arthur Young believes that Gliese 890 was once part of the Pleiades star cluster and was ejected toward us in space.

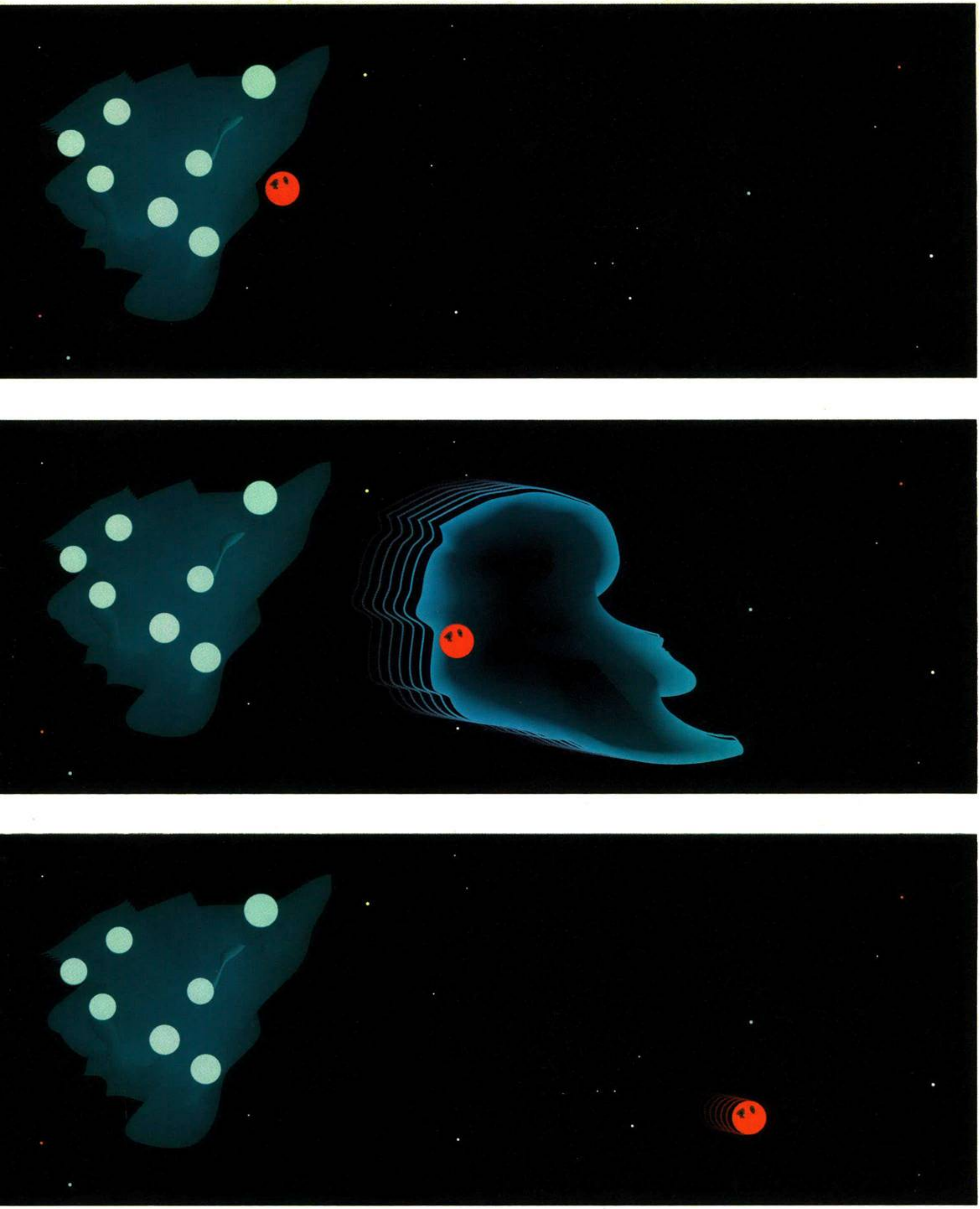
Here's how the scenario works: millions of years ago Gliese 890 was a typical red dwarf in the Pleiades. The star was gravitationally bound to the cluster and slowly orbited the Galaxy within the group.

Carried Away by Gravity

Several million years ago, Young believes, a massive molecular cloud passed close by the Pleiades and dispersed many of its members throughout surrounding parts of the Galaxy. This explains the Pleiades' anomalously low mass. Carried by the gravitational tug of the cloud, Gliese 890 headed toward us in space.

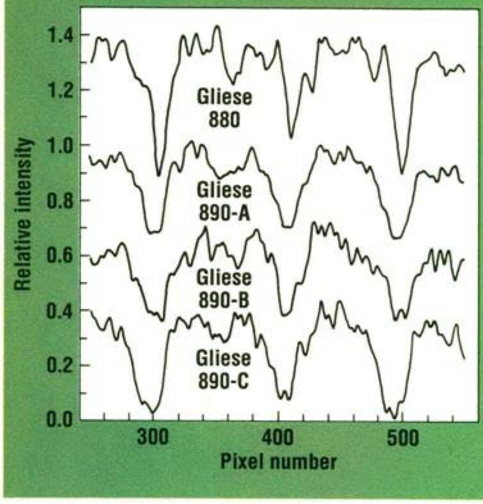
A Lone, Fast-Spinning Star

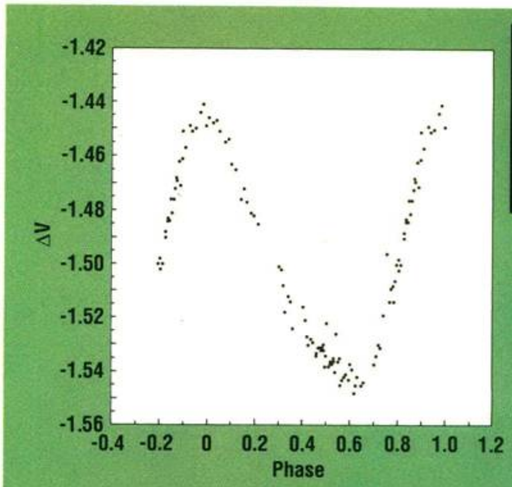
Still fleeing from its original birthplace, Gliese 890 today is a distant relative of the stars that still inhabit the Pleiades. The legacy of Gliese 890's past can now be measured in the star's fast rotation period, active magnetic field, occasional huge flares, and large starspots.



Lightning-Fast Rotation

Astronomers have determined that Gliese 890 is rotating at the astonishingly fast rate of 70 kilometers per second, 35 times faster than the Sun. The discovery was buried in the star's spectrum. The rapid rotation causes lines in the spectrum to broaden relative to other stars of the same type. This spectrum of absorption lines in neutral calcium shows that relative to the spectrum of Gliese 880 (top), different types of spectra of Gliese 890 are all much broader. Diagrams by Patti L. Keipe after Young, *et al.*



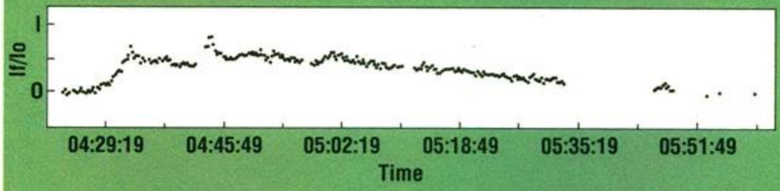


A Spotted Star

Gliese 890 is speckled, as evidenced by this light curve measured on September 3-5, 1983. The magnitude variation is caused by starspots — large dark areas on the star's surface.

A Star with a Temper

Curiously, for such a cool star, Gliese 890 has a hot temper. Erratically and without warning, the star has flared in brightness by a factor of two over time spans of just a few minutes. This diagram shows the brightness of Gliese 890 during a flare that was observed in 1983.



vary periodically the way it would if the star were revolving around a companion. Gliese 890 was spinning fast by itself; it had not been spun up to its high rotational velocity by a companion.

Astronomers began to wonder if there might be another way to approach the problem. In 1983 Scott Temple, now of the University of Washington in Seattle, found that the star's brightness varied by about a tenth of a magnitude every 10.3 hours. This variability is caused by starspots that come in and out of view as the star spins and means that the star rotates in just 10.3 hours.

"That was a wonderful confirmation," says Young, who had calculated what the rotation period should be if the star were spinning at 70 kilometers per second. "We predicted something like eight or nine hours, and the actual number my student, Scott Temple, found was ten hours."

Starspots and Stellar Flares

The starspots that cause Gliese 890's light to vary arise from the star's strong magnetic field, itself a product of Gliese 890's rapid rotation. Astronomers believe that a star needs convection and rotation to have a strong magnetic field. Gliese 890 has plenty of both.

Convection means that the star transports energy by bubbling and boiling. Hot gas rises to the top of the star, gives up its heat, then sinks back down again to collect more heat. The outer layers of all stars redder than spectral type F5 are convective. Astronomers observe such convection on the Sun's surface, and it presumably occurs on Gliese 890 as well. When the gas in these late-type stars rises, it carries magnetic field lines with it.

But convection alone is not enough to produce a strong magnetic field. The other requirement is rotation, which governs the convection and strengthens the field further. Stars like the Sun rotate differentially: the Sun's equator spins faster than its poles. A magnetic field line that stretches initially straight from the Sun's pole to its equator gets wound around and around as the Sun rotates, intensifying the magnetic field. The faster the rotation and greater the differential, the stronger the magnetic field gets. In a slowly spinning star like the Sun, with its rotation speed of two kilometers per second, the magnetic field is weak and the activity it produces is mild. Sunspots occur over a small fraction of the solar surface and produce occasional solar flares. A fast-spinning star — one with a rotational velocity of five or ten kilometers per second — has a stronger magnetic field and so many starspots that the light of the star fluctuates as the star turns.

Rotating at 70 kilometers per sec-

Gliese 890 and the Sun

	Gliese 890	The Sun
Right Ascension (2000.0)	**23h08.3m**	**—**
Declination (2000.0)	**–15°25'**	**—**
Distance	**65 ly**	**—**
Apparent Magnitude	**10.9 (v)**	**–26.72**
Absolute Magnitude	**9.3**	**4.9**
Relative Brightness	**0.017**	**1.0**
Spectral Type	**M2**	**G2**
Color	**Red**	**Yellow**
Temperature	**3600 K**	**5770 K**
Relative Mass	**0.5**	**1.0**
Relative Radius	**0.6**	**1.0**
Rotation Speed	**70 km/sec**	**2 km/sec**
Rotation Period	**10.3 hrs**	**One month**

ond, Gliese 890 must have a very strong magnetic field. Gliese 890's starspots are one consequence of this strong magnetic field. K and M dwarfs that vary in brightness because of starspots are called BY Draconis stars, after their prototype star in the constellation Draco. Many BY Draconis stars rotate faster than five kilometers per second and exist in binaries whose companions have spun them up. The rapid rotation produces the magnetic fields that cause the starspots that cause the variability. As in the case of Gliese 890, astronomers can measure the rotation periods of these stars by determining the periods of the stars' variability.

Another consequence of Gliese 890's rotation-driven magnetic field is huge stellar flares. In 1983 Bjørn Pettersen and colleagues of the University of Oslo discovered a gigantic flare on Gliese 890 that doubled the star's ultraviolet brightness in just a few minutes. Many other red dwarfs emit flares, too, and astronomers call these objects flare stars.

Did Gliese 890 Escape from the Pleiades?

Even as they study how rapid rotation affects Gliese 890, astronomers wonder how such an extreme star arose in the first place. The star must be very young, since it has not had time to brake its rotation. Yet, unlike other young stars, it's out there all by itself, rather than part of a star formation region like the Orion complex or a young cluster like the Pleiades.

Star clusters such as the Pleiades have told astronomers a lot about how stellar rotation decreases with age and provide strong evidence that Gliese 890 is very young. John Stauffer of the Harvard-Smithsonian Center for Astrophysics and others have found many fast-spinning, late-type stars in the Pleiades cluster. In fact, some K and M dwarfs in the Pleiades spin as fast as Gliese 890. The Pleiades is only 70 million years old, so its stars have not yet had time to spin themselves down.

Perhaps Gliese 890 is telling us that our theories of star formation are wrong. Astronomers believe that young stars form with thousands of other young stars in huge clouds of gas and dust. When the gas and dust disperse, the stars remain together in a star cluster like the Pleiades, which itself eventually disperses.

But perhaps all stars do not form in this way. Perhaps some, like Gliese 890, are born alone, without any neighbors. Gliese 890 may have started its life when a small, isolated cloud of gas and dust began to contract many millions of years ago. This small gas cloud formed a single, small, rapidly rotating star. The gas and dust dispersed, leaving us with a young isolated star that now casts doubt on our ideas concerning star formation.

Young prefers a different scenario, however. He notes that Gliese 890 is just like the rapidly rotating K and M dwarfs in the Pleiades. Although the Pleiades are farther from us than Gliese 890 — the cluster's distance is 410 light-years versus Gliese 890's distance of 65 light-years — Young thinks that Gliese 890 was actually once part of the Pleiades itself. Millions of years ago, though, the star somehow got ejected in our direction. "The space velocity of Gliese 890 fits the Pleiades remarkably, with only a small difference, which would be just what you'd expect if it were kicked out of the Pleiades," says Young. "Gliese 890 is nowhere near the Pleiades in the sky, of course — it's in the southern hemisphere. But that doesn't matter, because the Pleiades aren't that far away, and with a few kilometers per second velocity, Gliese 890 can make it to our part of the Galaxy in a few million years."

Young speculates that the Pleiades was once a much greater star cluster. He believes that a giant molecular cloud weighing a million times more than the Sun may have passed close to the Pleiades. The gravity of this huge cloud tore loosely bound stars from the cluster, including Gliese 890.

"One thing that is very striking about the Pleiades is that it's an anomalously small cluster," he says. "Open clusters typically have about a thousand times the mass of the Sun. But the Pleiades have perhaps two or three hundred times the mass of the Sun." This suggests that the original Pleiades star cluster may have lost over half its stars.

"I would guess that there are stars all over the sky that are former members of the Pleiades," says Young, who points to the star AB Doradus as another example. AB Doradus is a nearby, K-type star that rotates in just half a day. The star's strong magnetic field produces starspots and stellar flares, just as on Gliese 890.

"I think both of them are escapees from the Pleiades," he says. "There's a growing consensus that a lot of these low-mass, rapidly rotating stars we see are likely to be connected to the Pleiades — not all of them, but a lot of them."

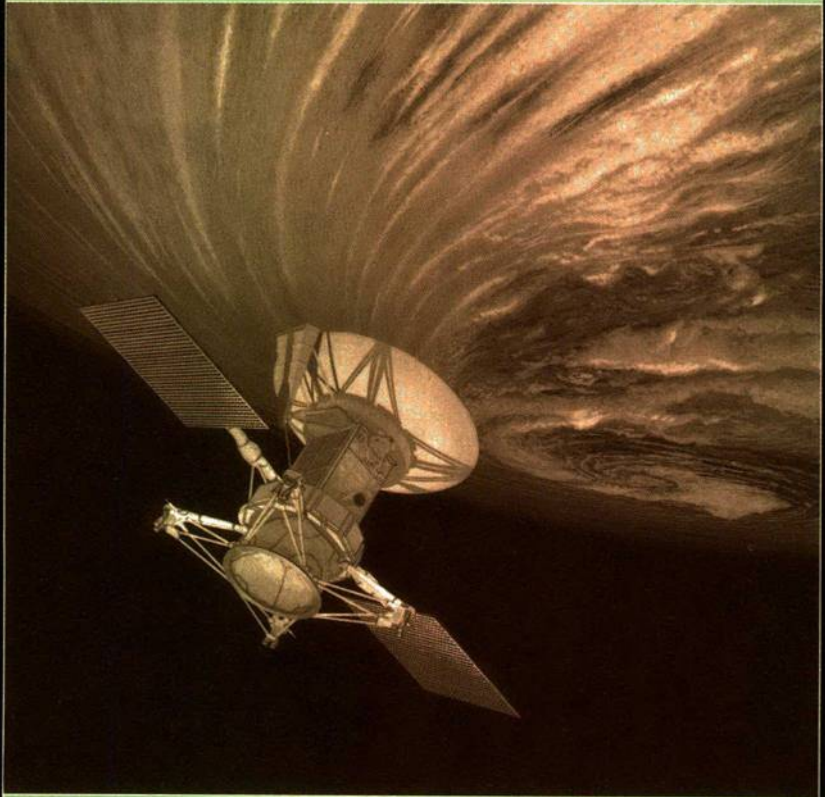
Whatever its origin, Gliese 890 offers astronomers the rare chance to study rapid rotation in a late-type single star, rotation that produces magnetic activity such as starspots and stellar flares. But the star's peculiar nature also suggests that Gliese 890 has had a most unusual history — a history that may involve one of the most beautiful star clusters in the sky. □

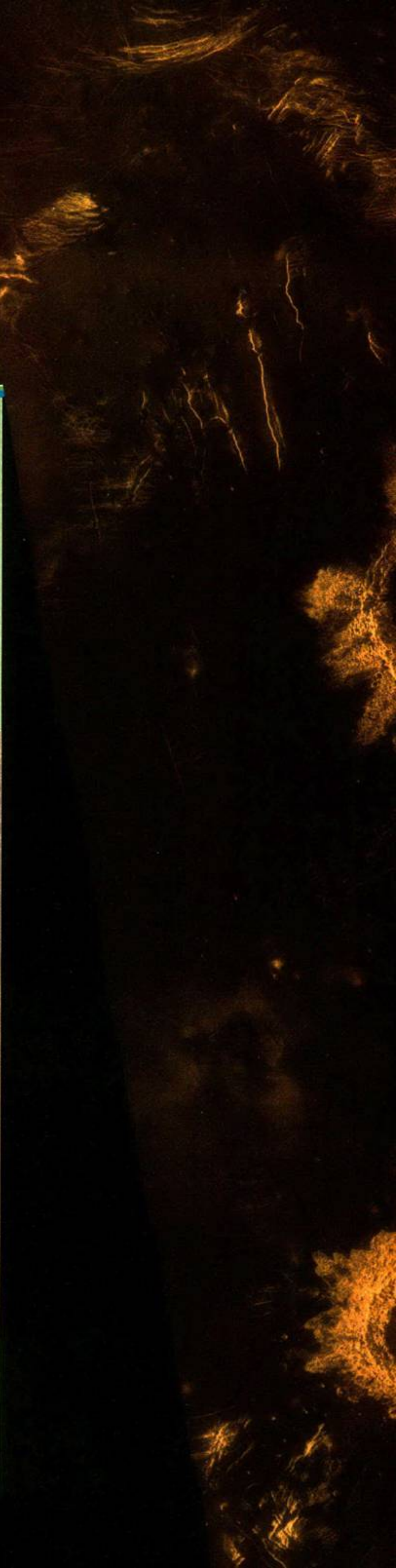
Ken Croswell received his doctorate in astronomy from Harvard University for studying the Milky Way Galaxy. He has written for Astronomy Now, New Scientist, *and Time-Life Books.*

Magellan Scores at Venus

A cloud-penetrating spacecraft strips Venus of its worn-out image and reveals a world active with volcanoes, mountains, surface cracks, and craters — an environment unique in the solar system.

by David J. Eicher





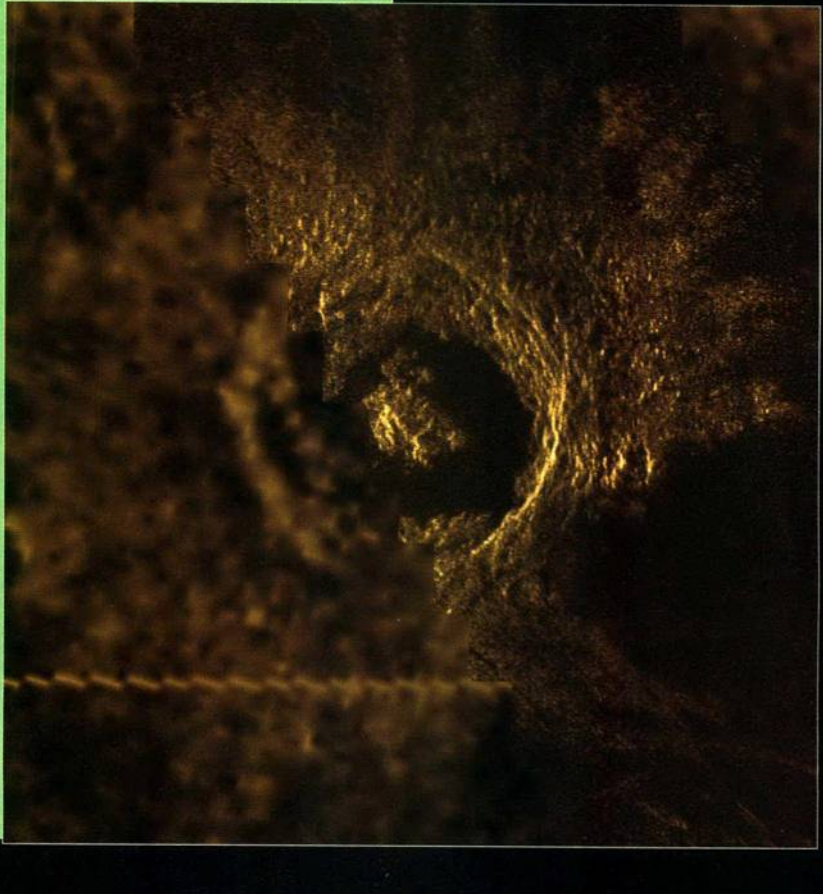
THE MAGELLAN SPACECRAFT arrived in orbit around Venus on August 10, 1990, promising to give astronomers their best look at Earth's "sister planet." After a few initial communications glitches, the craft performed admirably and returned radar images that astonished planetary scientists. At right three deep impact craters ranging from 23 to 30 miles across lie on a heavily fractured plain. Many volcanic domes are visible at lower right. Streaks north of the largest crater may represent sand dunes. All images courtesy NASA/JPL.

"This is absolutely some of the finest astronomical imaging ever collected!" As he scans several dozen pictures of Venus, Project Scientist R. Stephen Saunders has good reason for excitement. On August 10, NASA's *Magellan* spacecraft entered orbit around Venus after a 15-month, 950-million-mile-long journey. After several heart-stopping communications blackouts, the spacecraft began its mission of mapping the planet by radar on September 15. The mission is scheduled to last 243 days. *Magellan*'s images depict Venus in unprecedented detail, revealing objects as small as 400 feet across. (The previous best images, sent back by the Soviet *Venera 15/16* craft, had a maximum resolution of just under one mile — only 1/10 as good as *Magellan*'s.)

Although NASA has released only a trickle of *Magellan*'s first images, the quality of the new images sent a thrill of jubilation through the agency's *Magellan* staff. "It will be years before the images are analyzed," remarks Saunders. "But we can already see clearly a planet that has only been seen hazily before *Magellan*." James Head, a mission geologist borrowed from Brown University, believes the spacecraft is "giving us a revolutionary new view of Venus."

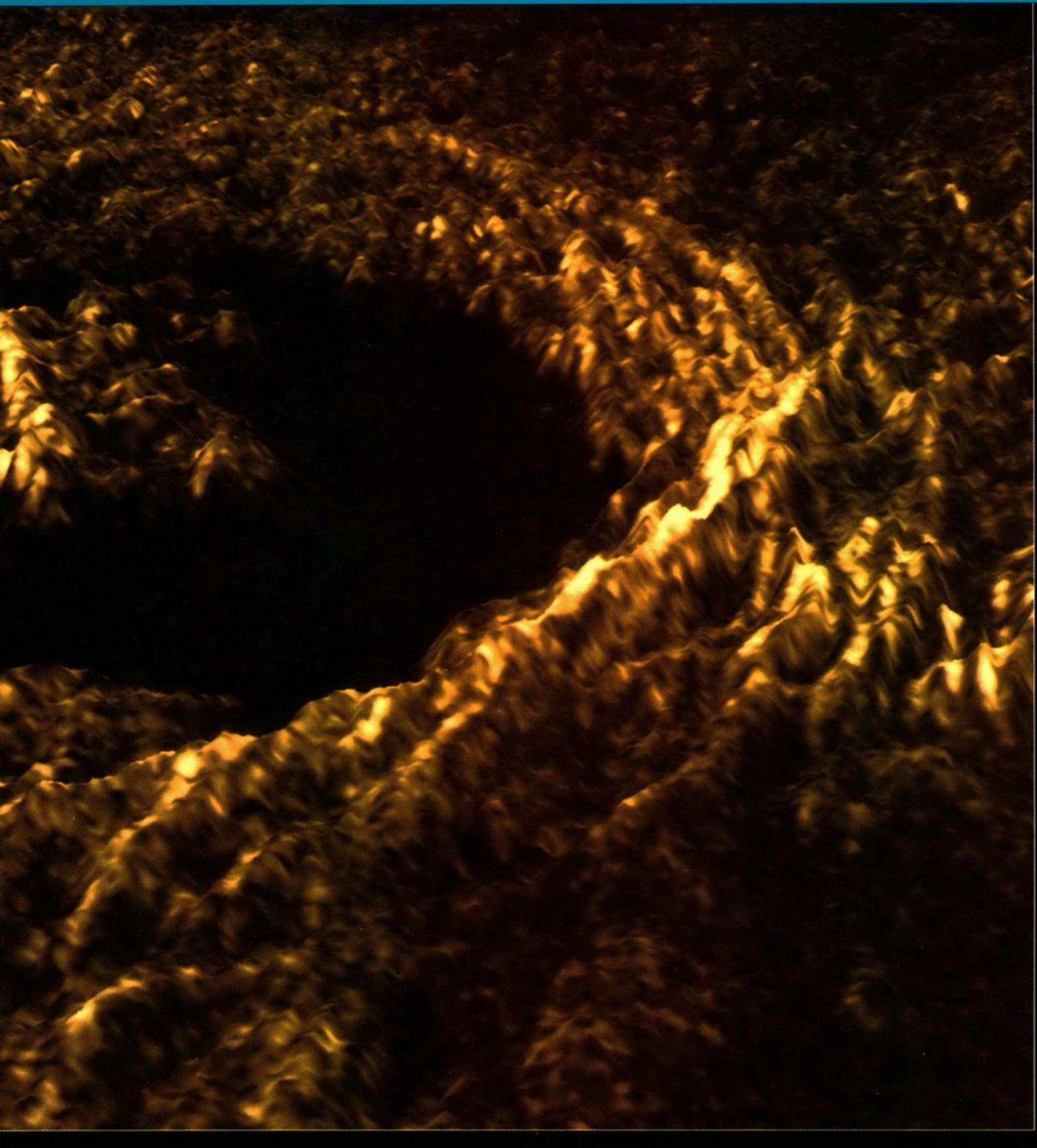
What's in the new views of Venus? "We've just started to examine them," says Saunders, "and the spacecraft has so far covered a very small area on the planet. We've seen all the familiar features we expected to see and some relationships that are really beginning to intrigue us."

"The most prominent things we expected to see are craters," declares Saunders. "We've produced a mosaic of a field in the Lavinia region that we call the 'crater farm' because of its three prominent craters and radar-bright blankets of ejecta. At first glance, Venusian craters appear similar to other solar system craters, like those on the Moon. We're seeing all of the typical characteristics — strong central peaks, terraced walls, and volcanically flooded floors. However, Venusian craters differ from lunar craters in that they have no bright rays caused by splatter — which does not happen easily in the thick Venusian atmosphere — and they have a radar-dark shock ring around



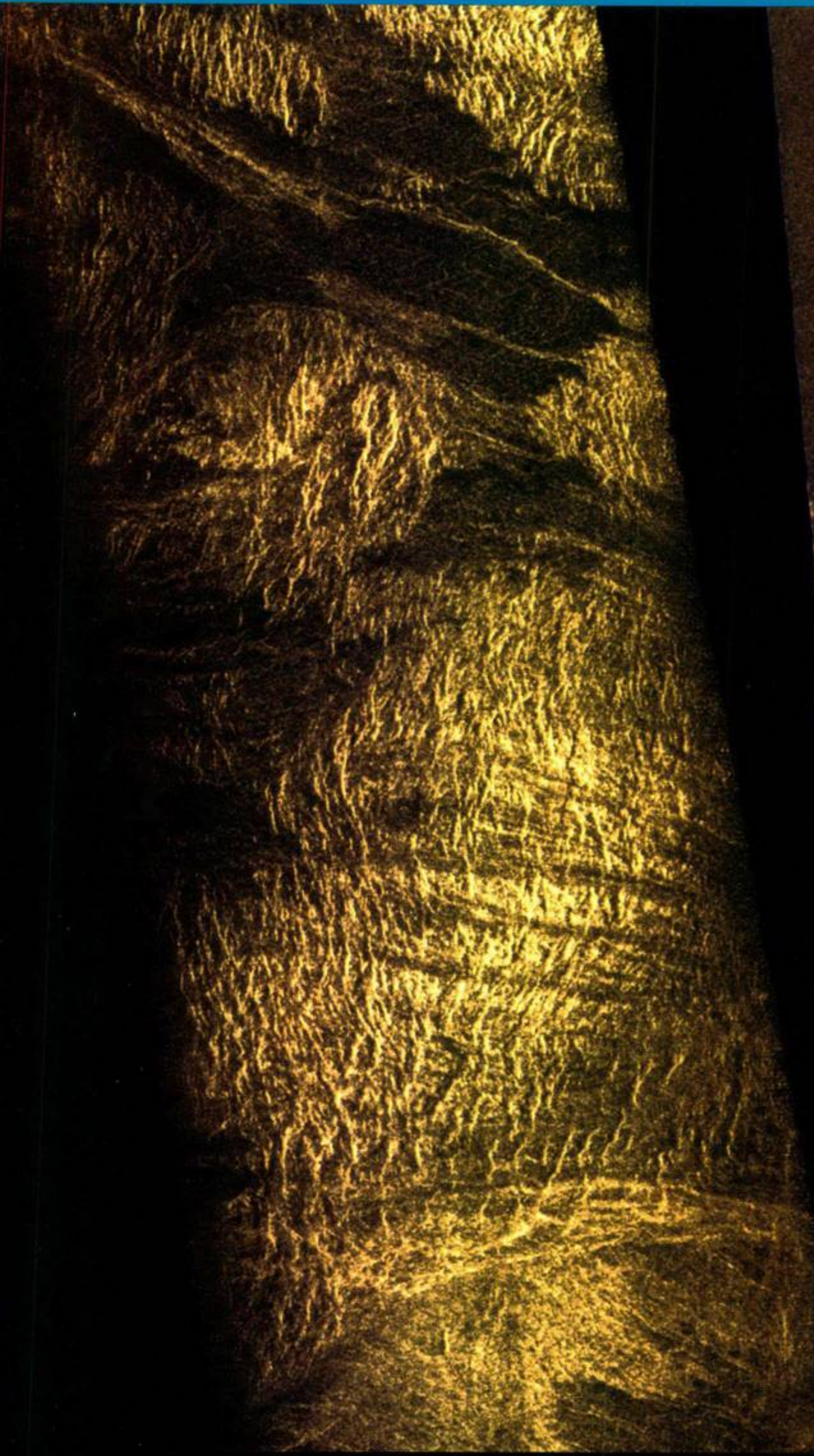
VENUSIAN CRATERS show terraced inner walls and a strong central peak, strikingly similar to craters on the Moon, Earth, and Mars. *Magellan*'s radar image of the crater Golubkina (below) shows details as small as 400 feet across, a tenfold increase in resolution over the previous best image collected by the Soviet *Venera 15/16* spacecraft (left side of the image). A three-dimensional computer reconstruction of *Magellan*'s picture of Golubkina reveals the third dimension of the structural features of the 20-mile-diameter crater (right).

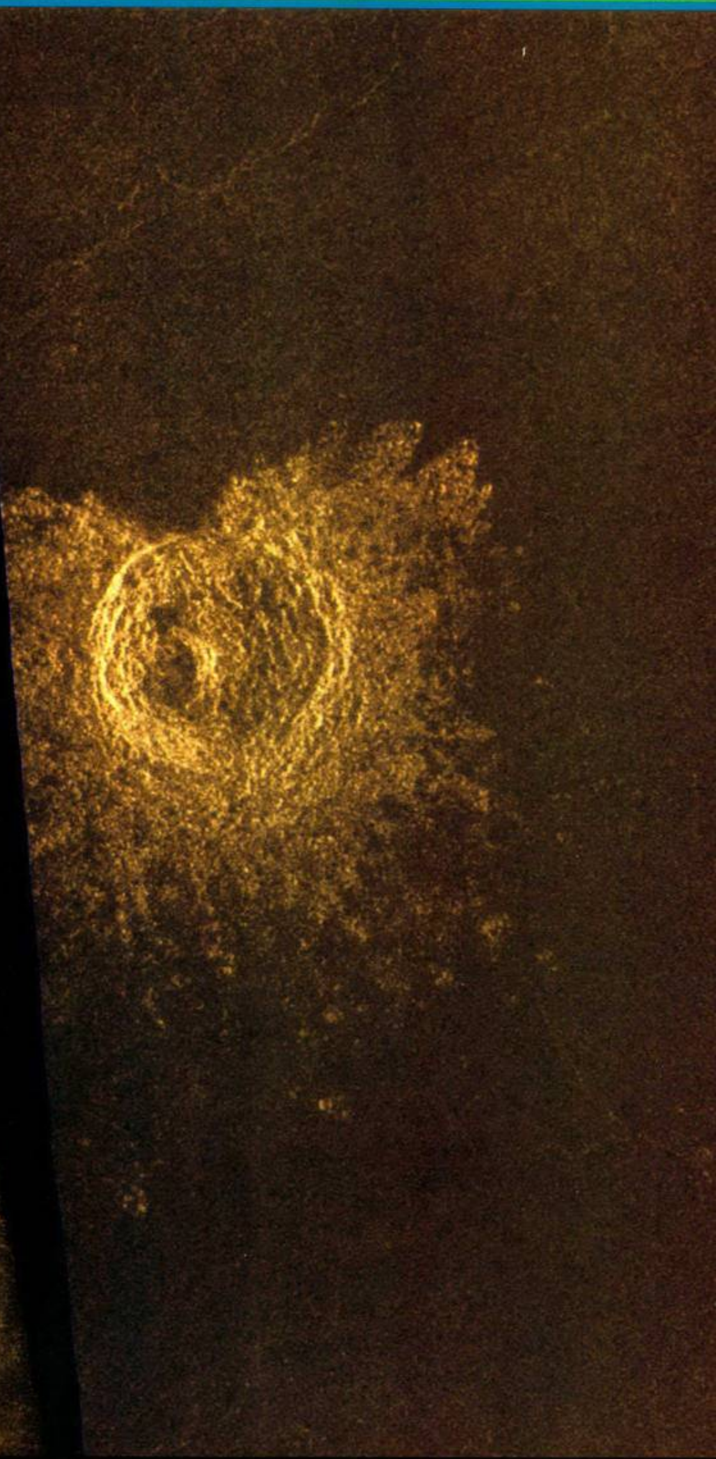
At first glance, Venusian craters look much the same as lunar craters. Yet Venus' craters are large and lack rays because of the planet's heavy atmosphere.



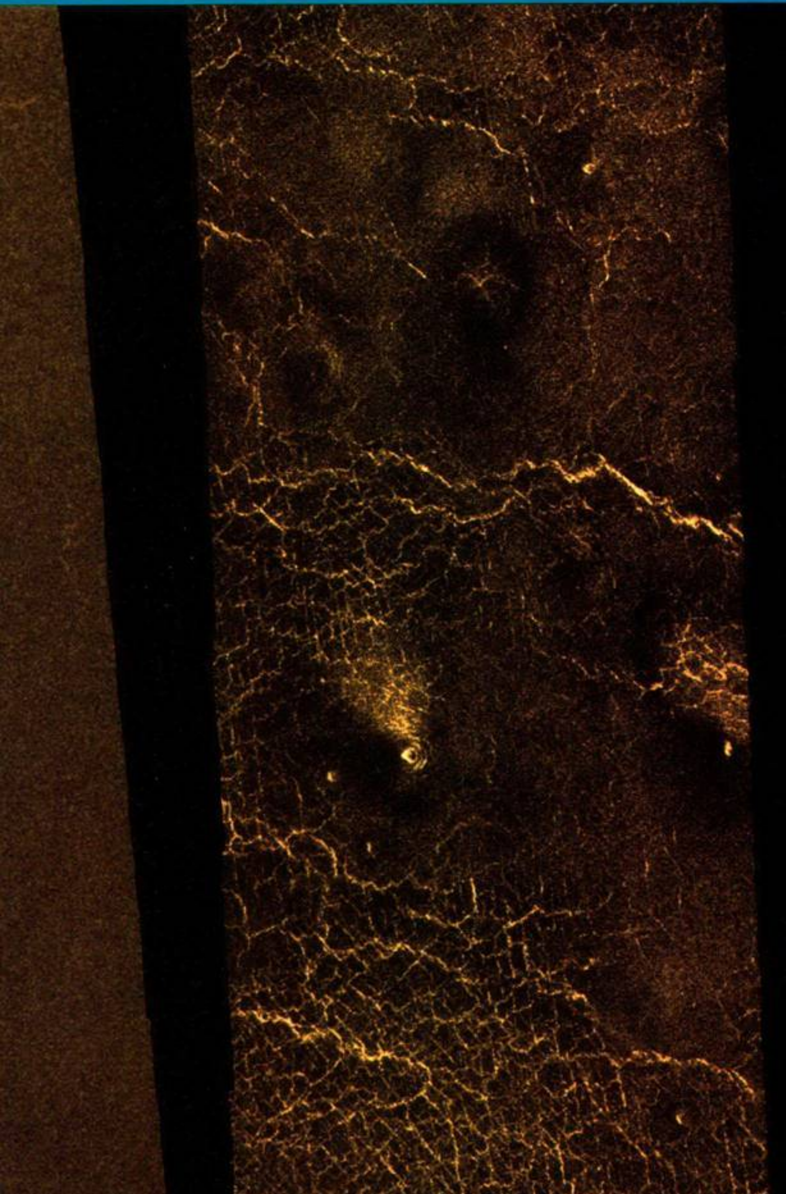
RIDGES AND VALLEYS crisscross this 28 by 81 mile chunk of Venusian landscape. The bright areas are ridges; the dark features at the top may be low-lying lava flows.

A BRIGHT EJECTA BLANKET surrounds an 8-mile-diameter crater in the Guinevere Planitia. The small asteroid that created the crater traveled at a shallow angle toward the bottom of the image.

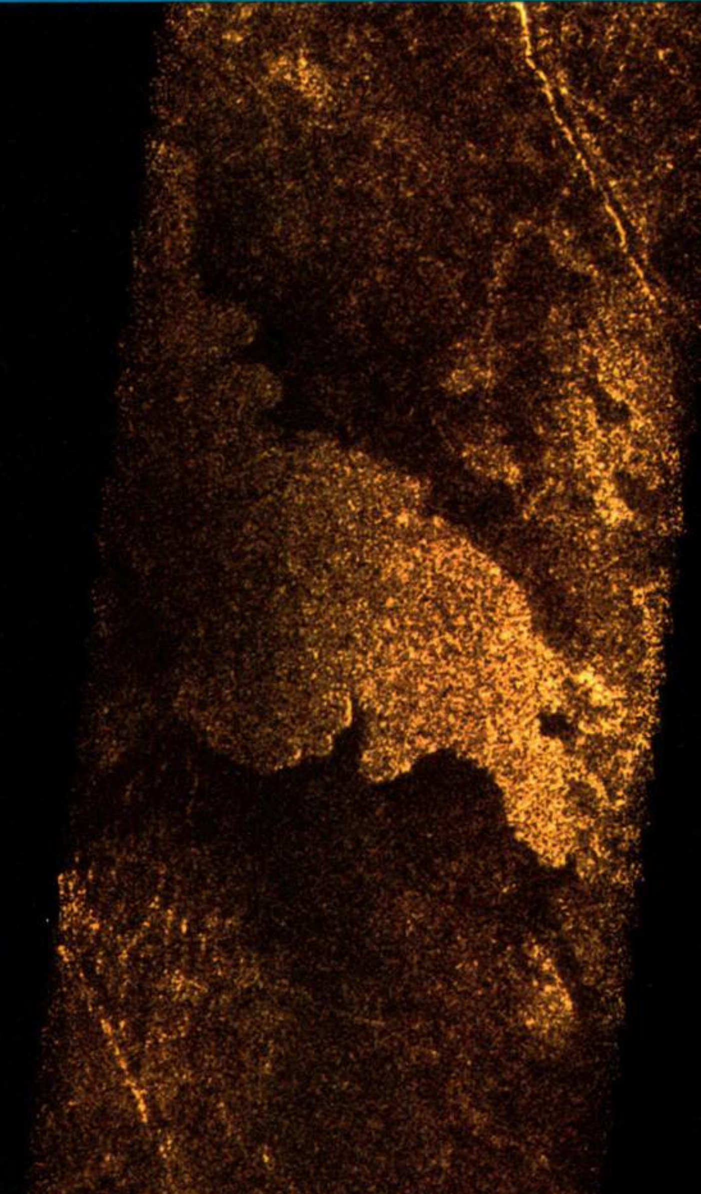




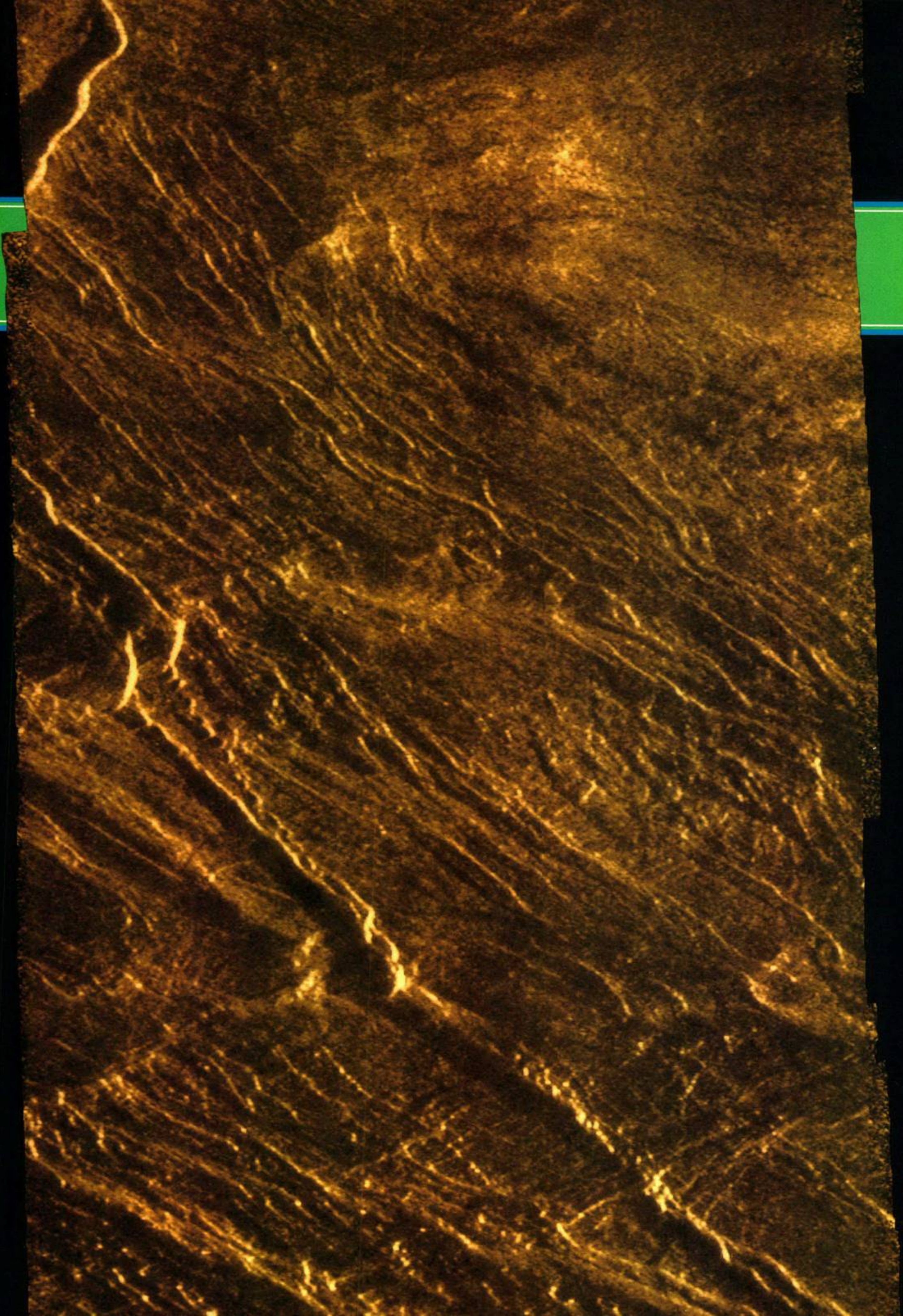
Is Cleopatra Terra an impact or volcanic feature? Does Maxwell Montes have huge faults like San Andreas? What are the secrets in these piles of rock?



EXPLOSIVE VOLCANISM may be occurring in this image centered on a crater less than one mile across. Surface deposits appear bright in radar because they are rough.

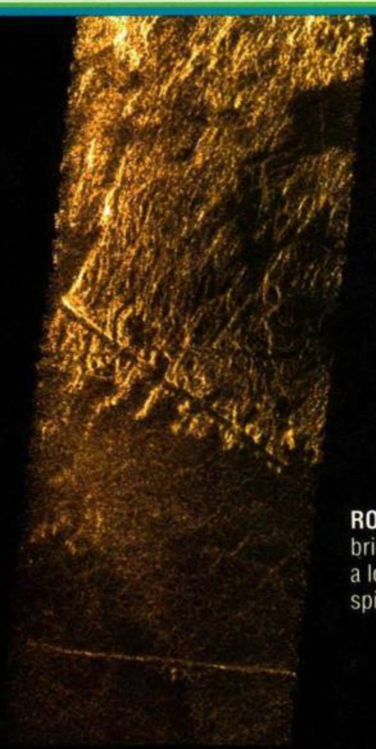


BURIED IN THE PAST, a dark plain is overrun by a rough lava bed that appears bright and extends from the center to the upper left corner. This image covers an area measuring about 20 by 47 miles.



MOUNTAINS AND VALLEYS run side by side for dozens of miles in the Lakshmi region of Venus. The twisting mountains rise nearly two miles above the floor of the plain, Lakshmi Planum, below.

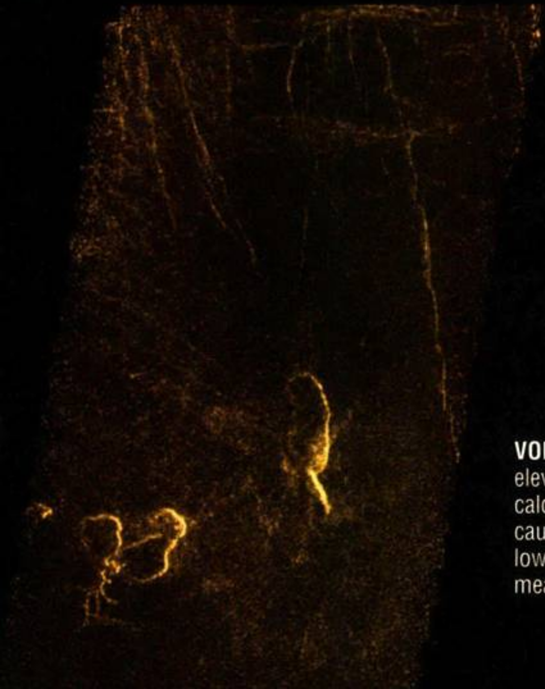
Venus' surface appears to be old, as if great activity happened early, resurfacing parts of the planet, and not much has happened since.

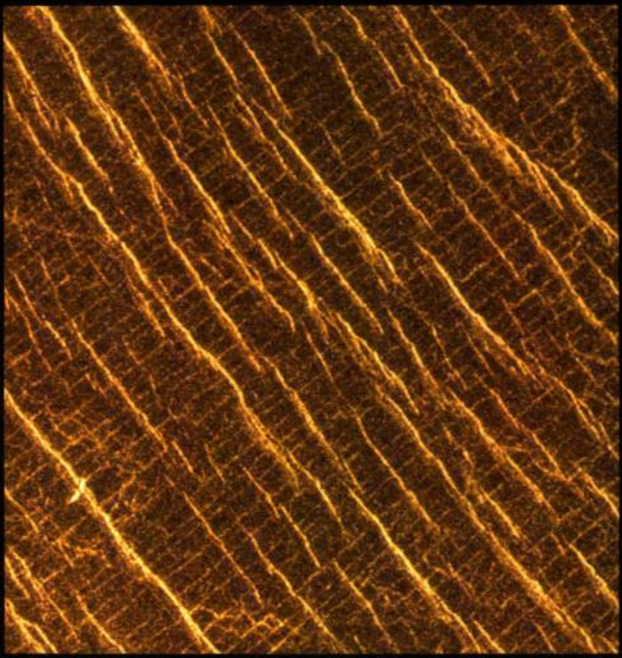


the ejecta. This is caused by a shock front created in the planet's atmosphere. Also, there are no small craters on Venus. Only large hunks of material make it through the atmosphere to the planet's surface."

Saunders points out another curious feature of the Venusian craters. "Perhaps the most startling thing about the craters is they all look the same," he says. "They're all fresh looking. In some areas there doesn't seem to be much going on that changes the planet's surface over time. This is amazing to me because it means that we might be looking at regions of a planetary surface that have been relatively unchanged from something like a billion years ago. This will be one of the big questions as *Magellan* research continues: Is Venus a planet that wants to turn itself inside out by volcanism every couple hundred million years and then just sit there for a while?"

ROLLING HILLS AND FRACTURED TERRAIN dominate the Phoebe region. The bright features in the top half of this image are hills; the dark terrain below is a low elevation plain, probably formed by overlapping volcanic flows. The conspicuous fault at center is just 500 yards wide.





VOLCANIC CALDERAS mark the low-elevation plains in the Phoebe region. The caldera walls appear bright most likely because they are rough; dark features mark lower elevations. The larger of the two measures 5 by 2 miles in extent.

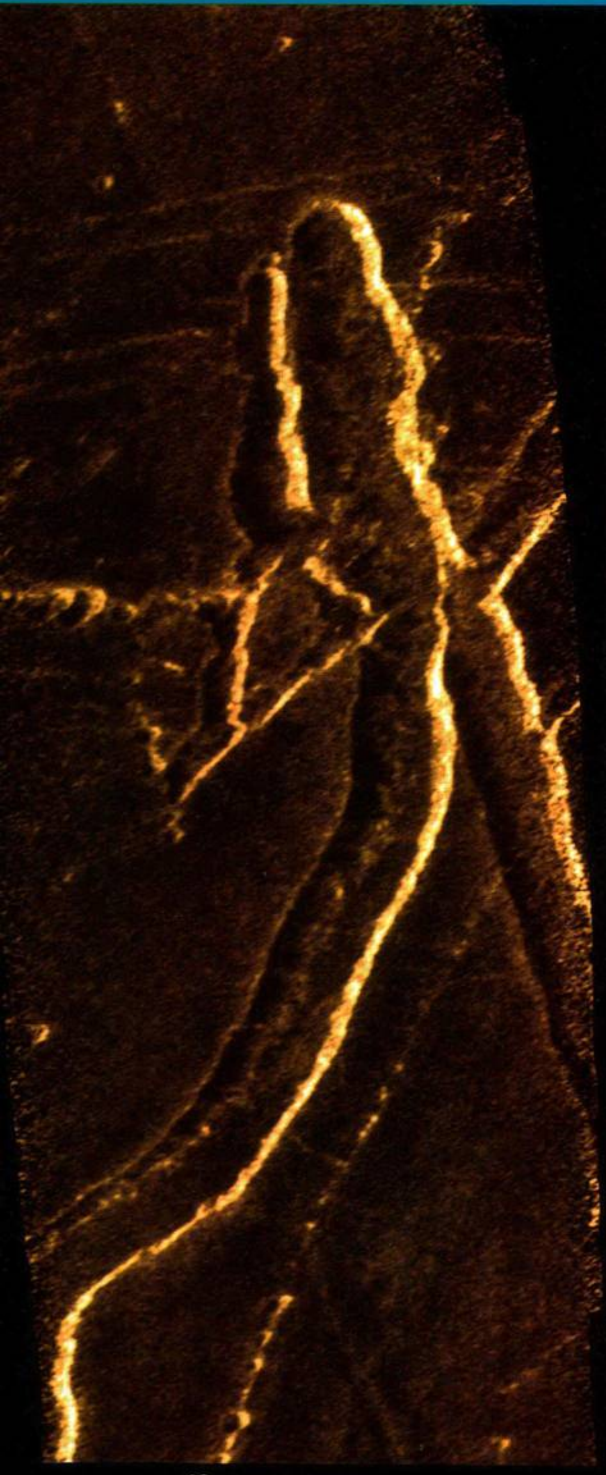
RADAR-BRIGHT PARALLEL LINES serve up a strange puzzle for astronomers, who believe the lines are either fracture or fault features. These features have not been previously observed on Venus or elsewhere in the solar system.

Magellan represents some of the most important astronomical images ever obtained — scientists will be sorting through them for years to come.

The planet's craters aren't its only geological attraction. Images sent back by *Magellan* show a detailed series of fracture and fault lines, volcanic features, and mountain chains that extend for hundreds of miles. "For example, in one image mosaic we call the crater farm," remarks Saunders, "we have detected a radar-bright patch of material extending out of the northern rim of the largest crater. If you look at where the bright patch north of the crater brightens and disappears, you can see some little glints that are suspiciously linear. That's just the way sand dunes look in radar when you get reflections off the steeper slip faces. We may have discovered the sand dunes of Venus!"

A volcanic dome centered in one of the images generated much excitement among the scientists. "Venus contains lots of little volcanic features here and there just like those on Earth," according to Saunders. "They're just right — the correct size, shape, and morphology. But I haven't yet seen any volcanic features that appear to be recent, and this is very surprising. I'm sure we'll eventually find recent volcanic activity, but so far — even in a volcanic plain — we've seen none." However, *Magellan* has thus far explored only a small percentage of the planet's surface.

"The really exciting part of the *Magellan* mission is the part to come," says Saunders. We'll see images of Maxwell Montes, a 7-mile-high mountain that is the highest point on Venus. We'll look at Cleopatra Terra, a 60-mile-diameter feature that may have either a volcanic or impact origin. Examining these and other areas will allow us to answer many questions we've had about Venus for years, and perhaps tighten our vision of how the planet works as a system. After all of the delays and the occasional glitch, it's almost unbelievable to think that the mission is now happening. People generally don't realize how important this mission is to our understanding of the solar system overall and to Earth science as well. We'll hear reverberations from this mission for years to come." □



DEEP TROUGHS ENCASED BY FAULTS characterize the most unusual feature in the planet's Lavinia region. The origin of this 50-mile-long feature is not clear. Unraveling the details of this and other features on our sister planet will challenge *Magellan* scientists for years to come.

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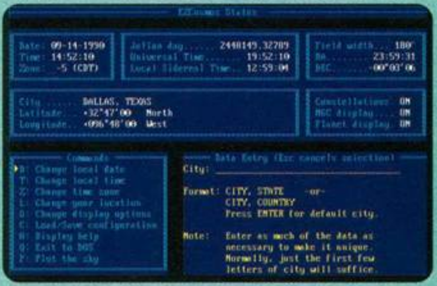

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Time: 14:52:10       Universal Time....... 19:52:10   RA......... 23:59:31
Zone:  -5 (CDT)      Local Sidereal Time.. 12:59:04   DEC........ -00°03'06

City...... DALLAS, TEXAS                              Constellations  ON
Latitude.. +32°47'00  North                           NGC display.... ON
Longitude.. +096°48'00  West                          Planet display. ON

Commands                       Data Entry (Esc cancels selection)
▸D: Change local date          City: ______________________________
 T: Change local time
 Z: Change time zone           Format: CITY, STATE    -or-
 L: Change your location               CITY, COUNTRY
 O: Change display options             Press ENTER for default city.
 C: Load/Save configuration
 H: Display help               Note:   Enter as much of the data as
 Q: Exit to DOS                        necessary to make it unique.
 P: Plot the sky                       Normally, just the first few
                                       letters of city will suffice.
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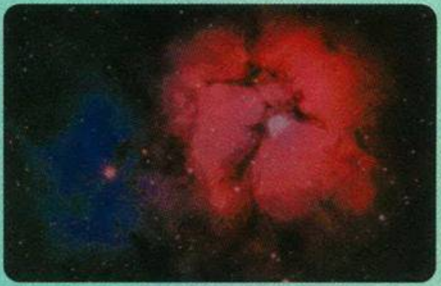
The status screen lets you choose the date, time and location.



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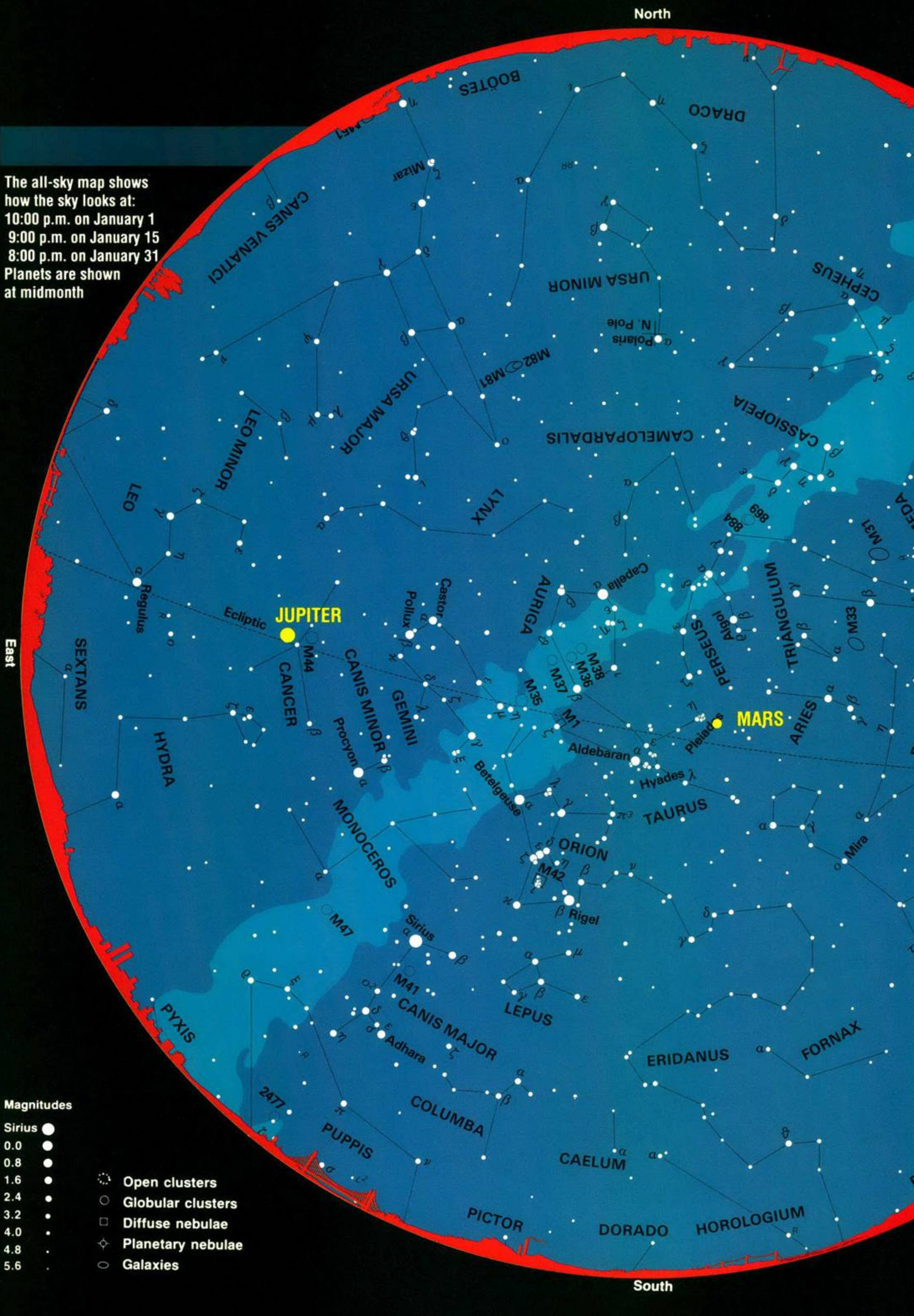
The all-sky map shows how the sky looks at:
10:00 p.m. on January 1
9:00 p.m. on January 15
8:00 p.m. on January 31
Planets are shown at midmonth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URSA MAJOR
LEO MINOR
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CASSIOPEIA
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Regulus
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Castor
AURIGA
Capella
PERSEUS
Algol
TRIANGULUM
M33
SEXTANS
CANCER
CANIS MINOR
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M37
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M1
MARS
Pleiades
ARIES
HYDRA
Procyon
Betelgeuse
Aldebaran
Hyades
TAURUS
MONOCEROS
ORION
M42
Rigel
Mira
M47
Sirius
M41
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Adhara
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ERIDANUS
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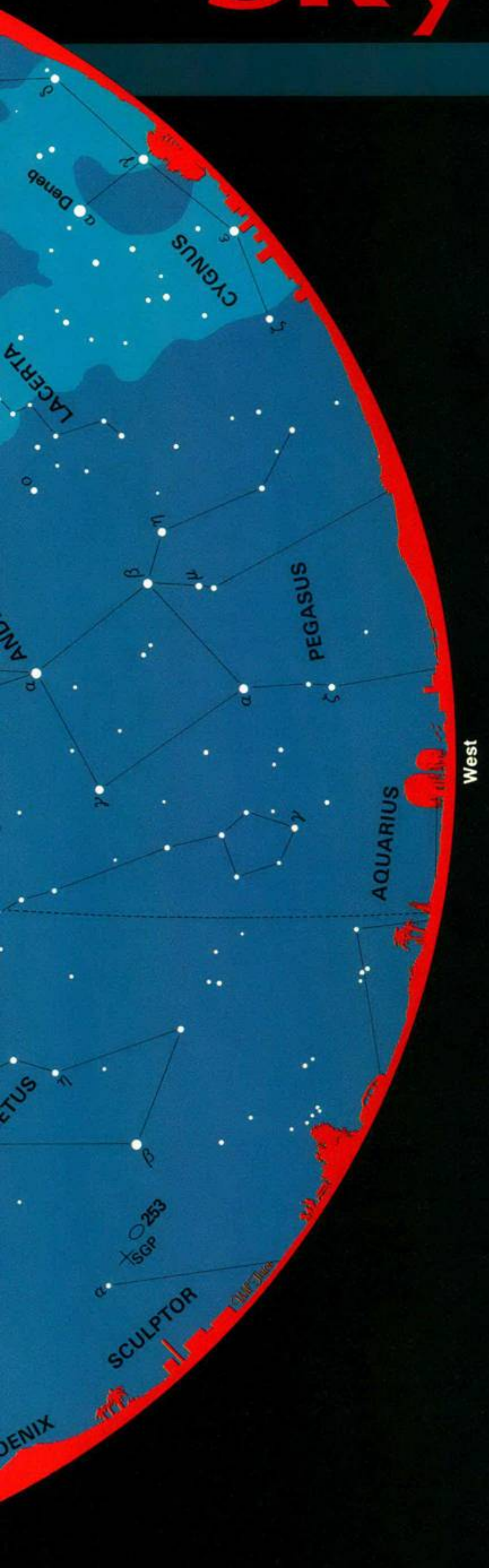
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

January 1991



JUPITER AT ITS BEST

Jupiter reaches opposition on January 28/29, which means the plan-et is at its brightest for the year and visible all night long. The –2.6-magnitude planet offers telescopic observers evolving atmospheric features and a large number of mutual events among its satellites.

LUNAR ECLIPSE ON JANUARY 29/30

Observers throughout North America can see an eclipse of the Moon on the night of January 29/30. The Moon's northern limb will darken slightly as it passes through Earth's penumbral shadow.

VENUS RETURNS IN THE EVENING SKY

For the past several months Venus has lurked so near to the Sun that it has been difficult if not impossible to see. But the brightest planet becomes conspicuous in the southwest after sunset this month, a prelude to its fine evening apparition this spring and summer.

Calendar of Events

1 Venus passes 1.2° south of Saturn, 10 a.m. EST
Asteroid Herculina is at opposition

2 The Moon passes 2° south of Jupiter, 6 p.m. EST
Earth is at perihelion, 10 p.m. EST

4 Quadrantid meteor shower peaks Neptune is in conjunction with the Sun

7 Last Quarter Moon is at 1:35 p.m. EST

11 The Moon passes 0.6° north of Antares, 10 p.m. EST

12 The Moon is at apogee (252,300 miles from Earth), 6 a.m. EST

15 New Moon is at 6:50 p.m. EST; annular solar eclipse

17 The Moon passes 3° north of Venus, 1 p.m. EST

18 Saturn is in conjunction with the Sun

23 First Quarter Moon is at 9:21 a.m. EST
Mercury passes 0.4° north of Uranus, noon EST
Asteroid Metis is at opposition

25 The Moon passes 2° north of Mars, 10 a.m. EST

28 The Moon is at perigee (224,924 miles from Earth), 4 a.m. EST
Jupiter is at opposition

29 The Moon passes 1.8° south of Jupiter, midnight EST

30 Full Moon is at 1:10 a.m. EST; penumbral lunar eclipse

Eye on the Sky by Deborah Byrd

DAZZLING JUPITER REACHES OPPOSITION

When the new year begins, the solar system's largest planet is rising in the east-northeast not long after the Sun goes down. It rises progressively earlier each evening until, on the night of January 28/29, it is a brilliant white object that rises just as the Sun sets.

This is Jupiter's opposition, when it appears opposite the Sun from Earth. It happens because — for a fleeting time — the Sun, Earth, and Jupiter form a straight line in space. This celestial line-up is largely Earth's doing, a result of our passing between the Sun and Jupiter as we travel in our smaller and faster orbit.

With Jupiter gleaming at magnitude –2.6, this is a good month to view the giant planet through binoculars. With a steadily held pair, you can glimpse one, two, or even more of the planet's four largest moons, called the Galilean satellites after their discoverer. If you don't have a tripod, try sitting on the ground and bracing the binoculars against your knees, or placing your elbows on the hood of a car, for support.

THE MOON IN EARTH'S SHADOW, BARELY

Jupiter appears near the Moon during the night of January 29/30, and on this night a subtle kind of lunar eclipse, called a penumbral eclipse, can be seen throughout North America. All lunar eclipses take place at Full Moon, when the Moon wanders into Earth's shadow. This shadow consists of a dark central umbra and a lighter surrounding penumbra. When the Moon passes deep enough into the shadow, a dark umbral eclipse occurs. Then the Moon looks like it has a dark "bite" taken out of it. It may become fully submerged in the dark part of the shadow, in which case there is a total eclipse of the Moon.

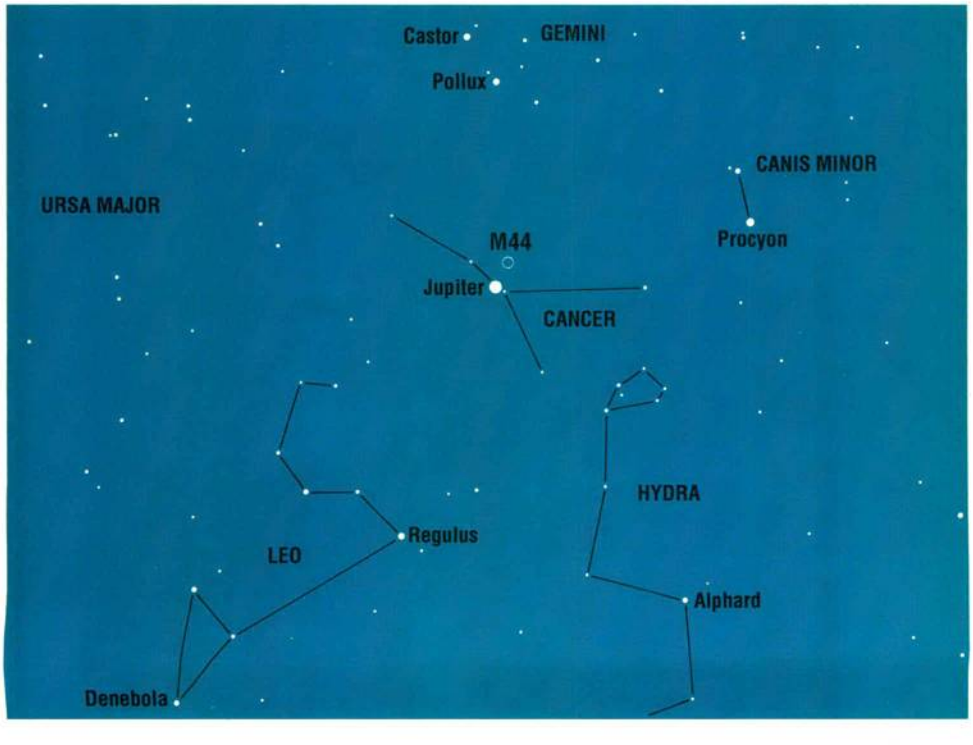
In this month's eclipse, neither of the above happens. The Moon merely glides through the lighter penumbral shadow, beginning at 10:58 p.m. EST. Unless you are extremely perceptive, nothing will appear to happen at first. But by mid-eclipse at 12:59 a.m. EST, most people will be able to see the dusky shading that covers the northern part of the Moon.

Be forewarned, however: this is not a good eclipse for amazing your family and friends. Take any two people with average eyesight, stand them outside on a clear night, and show them the Moon in penumbral eclipse. One will enjoy it very much, while the other swears that nothing at all unusual is taking place.

THE RETURN OF VENUS

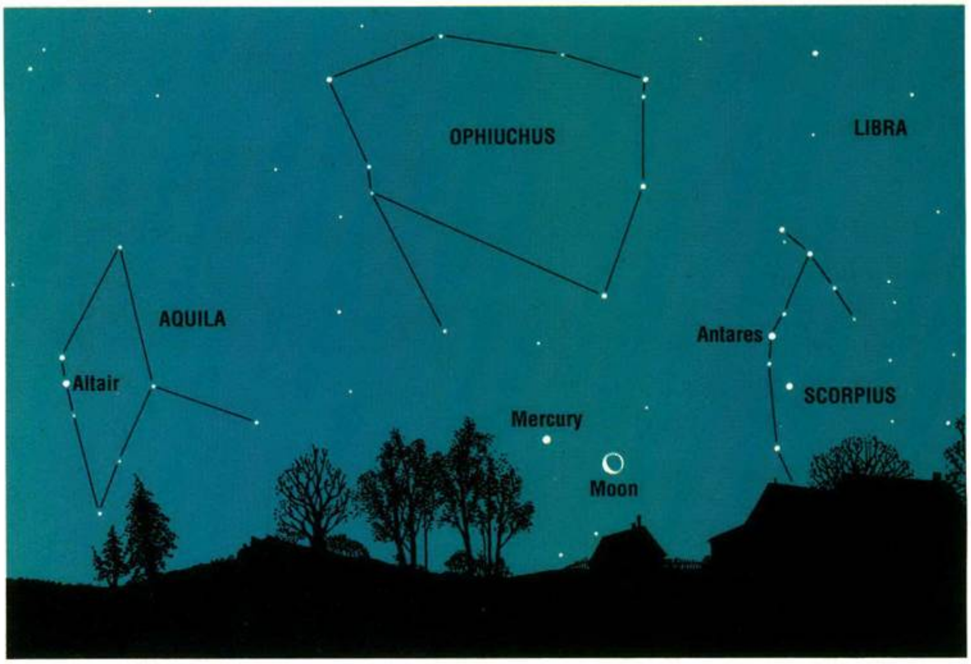
The brightest of all the planets, Venus, was lost in the Sun's glare for most of last autumn. If you were lucky, you might have glimpsed it toward the end of December, hanging very low in the evening twilight. This month it returns to glory, shining at magnitude –3.9, in the evening sky. The fainter point of light near it during the first few days of the month, perhaps visible only through binoculars, is Saturn.

JUPITER DOMINATES the nighttime sky in late January, as it reaches opposition and is at its brightest for the year. Look for the planet in the east during mid-evening.



Venus, still far from Earth, will pull closer to us over the next several months as it speeds along in its faster orbit. It will pass between us and the Sun before the end of summer. Between now and then it will ascend in the evening sky, to appear as the dazzling "evening star" this coming spring.

Early stargazers called Venus by different names during its morning and evening apparitions. It's often said that they believed it was two different objects! Venus was known as Hesperus, or Vesper, when it appeared in the evening, and Phosphorus, or Lucifer, when it appeared in the morning.



ELUSIVE MERCURY is reasonably easy to find this month, particularly on the morning of the 13th when the Moon helps point the way. The pair lies about 10° above the southeastern horizon thirty minutes before sunrise.

JANUARY'S PLANETS

Venus can be found low in the southwest each evening, shining brilliantly at magnitude –3.9. Look for it as soon after sunset as possible from a location where the horizon isn't obstructed by trees or tall buildings. It's a lovely sight near a slim crescent Moon on the evening of January 17.

You might spot Saturn on the first day or two of the new year. It surely wouldn't be noticeable, however, if it weren't located just 1.2° north of Venus on January 1. Even then, it is some 60 times fainter than Venus. You might need binoculars to see it against the bright twilight background.

After this close approach, Saturn quickly sinks out of sight and passes behind the Sun on January 18. It will return to the predawn sky in early February.

Mars shines brightly against the backdrop of the constellation Taurus, in the company of winter's bright stars. But the planet continues to fade during the course of the month, from magnitude –1.0 on January 1 to magnitude –0.1 on the 31st.

What's more, Mars is stationary, or poised motionless in front of the stars of Taurus, on January 1. After that it resumes eastward motion. This is a sure sign that Earth is now far ahead of the Red Planet in its orbit. Although Mars remains in our evening sky until early autumn, it will fade and be visible for shorter periods each night between now and then.

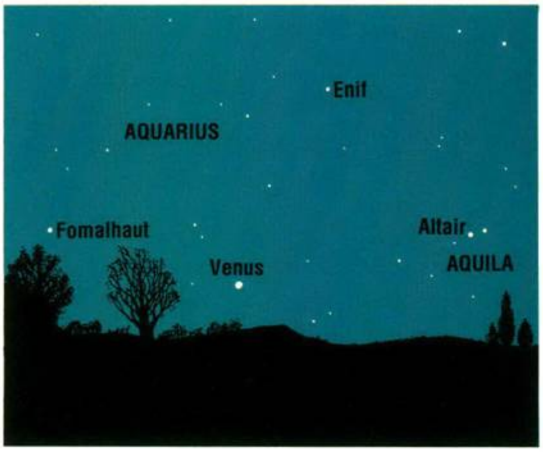
Jupiter reaches opposition on the night of January 28/29. It dominates the winter night, shining at magnitude –2.6 in the constellation Cancer. In a dark sky with the naked eye, you can see a hazy patch near Jupiter. This is the star cluster called the Beehive, or Praesepe.

Jupiter appears near the Moon twice this month. It lies 2° north of the gibbous Moon on the evening of January 2, and less than 2° north of the Full Moon on the night of January 29/30.

Jupiter is the largest planet in the solar system. If it had only about 80 times more mass, it would be a star. This month, as Jupiter ascends in the east after sunset, it's fun to imagine the sky's appearance if Jupiter had been born with this additional mass. Around now, with the planet at opposition, there would be no night at all — and no observing!

Innermost Mercury is visible before dawn all month. Look for the planet in the southeast 30 to 45 minutes before sunrise. Don't mistake

VENUS CLIMBS HIGHER in the evening sky during January and becomes easy to see for the first time since last summer. The brightest planet can be found low in the southwest about thirty minutes after the Sun sets.



it for the orange star Antares, which is located above and to the right of the planet and shines at about the same brightness when the month begins. The waning crescent Moon sweeps near the planet on January 13. Greatest elongation comes one day later, when Mercury lies 24° west of the Sun. Then the planet shines at magnitude –0.2.

THE STARRY SKY

On crisp winter evenings, the sky overhead glitters with bright stars. This is because we are now looking outward from the center of the Milky Way Galaxy, into the spiral arm nearest us.

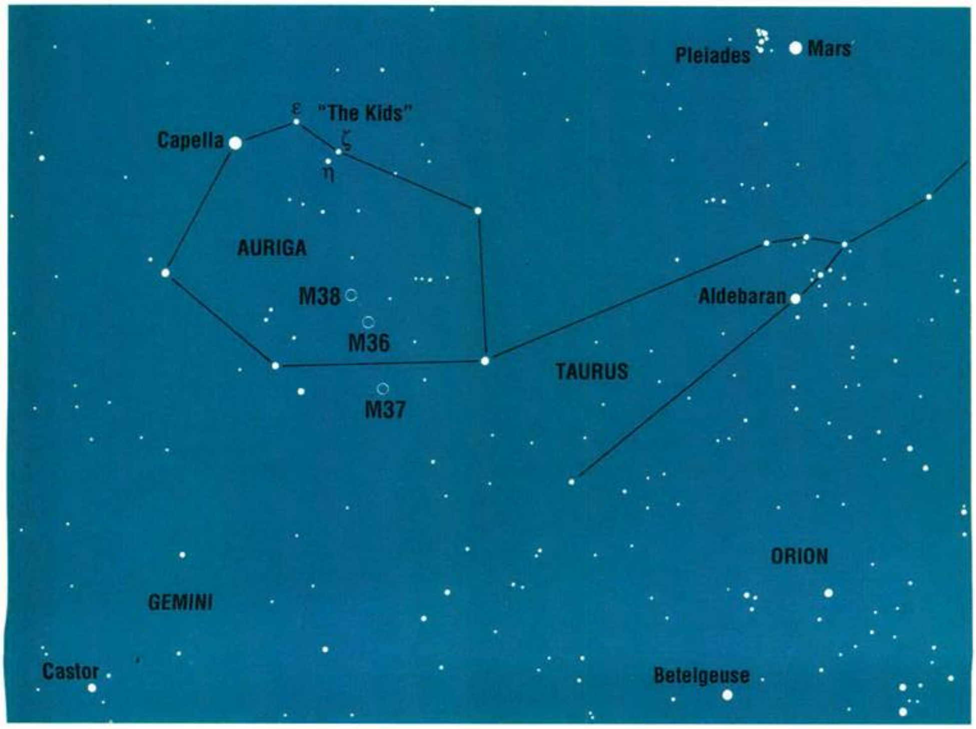
One of the brightest stars of the winter sky is Capella, in the constellation Auriga the Charioteer. Capella is closer to the sky's north pole than any of the sky's other 1st-magnitude or brighter stars. It marks the northwest corner of Auriga, a five-sided figure that is easy to pick out, even from small cities.

The stars of Auriga were pictured on the star maps of many ancient cultures as a man who holds reins and a whip in one hand and a she-goat with its two kids in the other. Capella, Auriga's brightest star at magnitude 0.08, is sometimes called the Goat Star. It is a multiple star system, thought to consist of three or four stars, located 42 light-years away.

Near Capella is a little asterism of three fainter stars: Eta (η), Epsilon (ε), and Zeta (ζ) Aurigae. These three form a small triangle called "the Kids."

Epsilon Aurigae is one of the sky's most intriguing stars. It is a 3rd-magnitude star that appears to undergo a two-year-long eclipse, during which its brightness drops by about half, once every 27 years. This happened most recently from 1982 to 1984. It used to be thought that these eclipses were caused by a gigantic but faint star orbiting Epsilon, but now the best guesses include a shell of gas and dust surrounding an orbiting star.

AURIGA THE CHARIOTEER rides high in the east during the early evening hours of January. The constellation has a distinctive pentagonal shape and boasts the sky's sixth brightest star, Capella.



Auriga is one of the oldest constellations, sometimes associated with a mythical early king of Athens, called Erechtheus, who is said to have invented the chariot. In another legend, the charioteer is Phaethon, son of Sun god Helios. When his father consented to let him drive the chariot of the Sun for one day, Phaethon was unable to control the powerful horses. The chariot plunged toward Earth, creating the Sahara desert, before Zeus took aim with a thunderbolt and ended the boy's wild ride.

The faint starlit trail of the winter Milky Way runs through Auriga. That makes this constellation a rewarding area to scan with your binoculars. In particular, look for the three bright open star clusters — M36, M37, and M38 — located in southern Auriga. □

Deborah Byrd is the creator, writer, and producer of "Star Date," an independently syndicated daily radio series on commercial and public radio.

Through the Eyepiece by Rick Shaffer

CHANGES IN THE JOVIAN ATMOSPHERE

Jupiter reaches the best visibility of its current apparition on the night of January 28/29, when the gas-giant planet is at opposition. On that night, Jupiter rises at sunset, is highest in the sky around midnight, and sets at sunrise. Because opposition coincides with the long nights of January, you can witness a complete rotation of Jupiter's cloudtops during the course of an all-night observing session. And with the planet experiencing an unusual level of atmospheric activity, there is plenty to look at.

Jupiter has presented a lopsided appearance for much of the past year, a consequence of the near invisibility of the planet's South Equatorial Belt. As if to offset the loss of the SEB, however, the Great Red Spot appeared noticeably redder. Now, as I write this in mid-October, the SEB is making a strong comeback while the Red Spot appears to be fading. And all indications are that these trends will continue.

Because the SEB and Red Spot are adjacent to one another, they most likely interact on some level. In fact, "rotation movies" taken during the *Voyager* flybys showed that the Red Spot occasionally swallows smaller spots trying to move along the SEB. However, those movies were taken when both the SEB and the Red Spot were bright, a different situation than we see now.

To get a front-row seat at this continuing drama, you'll need to observe from a site that gives you a good chance at getting some good seeing. You know the drill by now: avoid asphalt parking lots and other areas that absorb the Sun's heat during the day and release it at night. Also, give your telescope an hour or so to reach thermal equilibrium with its surroundings.

Jupiter's current position along the northern part of the ecliptic confers a natural advantage to viewing the planet this apparition. It currently lies among the background stars of Cancer at the relatively high declination of 18°. That places the planet high in the sky — where the seeing is usually better — for Northern Hemisphere observers. From a latitude of 40° north, Jupiter reaches a peak altitude of 68° around midnight. Although it won't get as high if you live farther north (losing 1° of altitude for each 1° of latitude), it climbs even higher in the sky if you live farther south.

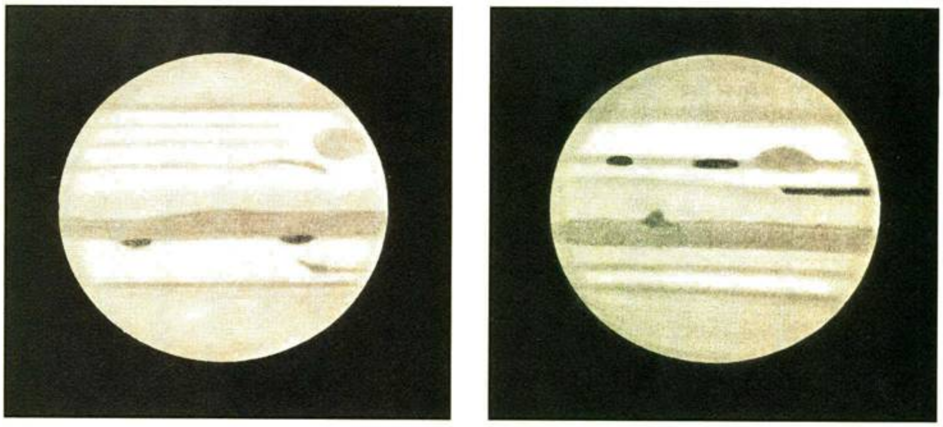
Jupiter is bright enough, at magnitude –2.6, and appears large enough, with an apparent diameter of over 45", that you won't need a lot of power to get a large image. If the seeing is steady, try using a power of about 25x for each inch of aperture (or 1x for every millimeter). If the image of Jupiter remains sharp at that magnification, you can bump it up a little more.

Although the atmosphere of Jupiter has received the lion's share of this month's fanfare, that doesn't mean the planet's Galilean satellites are not worth viewing. In fact, the moons of Jupiter offer so much to telescopic viewers this month that they've received their own article. See "Jupiter's Moons Play Tag" on page 58 for the complete story on the series of mutual occultations and eclipses taking place among the Galilean satellites. The pace of these mutual events picks up dramatically this month, to an aver-

GALILEAN SATELLITE PHENOMENA

Date	Event	Time
	IO	
Jan. 15	Shadow enters	5h25m
	Transit begins	5h45m
	Shadow leaves	7h42m
	Transit ends	8h02m
Jan. 23	Eclipse begins	4h33m
	Occultation ends	7h00m
Jan. 30	Occultation begins	6h26m
	Eclipse ends	8h46m
Jan. 31	Transit begins	3h38m
	Shadow enters	3h41m
	Transit ends	5h55m
	Shadow leaves	5h58m
	EUROPA	
Jan. 15	Shadow enters	5h04m
	Transit begins	5h46m
	Shadow leaves	7h59m
	Transit ends	8h41m
Jan. 31	Occultation begins	4h46m
	Eclipse ends	7h45m
	GANYMEDE	
Jan. 6	Shadow enters	5h39m
	Transit begins	7h51m
	Shadow leaves	9h13m
	Transit ends	11h27m
Jan. 24	Eclipse begins	3h40m
	Occultation ends	7h47m
	CALLISTO	
Jan. 28	Shadow enters	0h58m
	Transit begins	1h10m
	Shadow leaves	5h41m
	Transit ends	5h54m

Times are given in universal time. Subtract 5 hours to convert to EST, 6 hours for CST, 7 hours for MST, and 8 hours for PST.



JUPITER'S SOUTH EQUATORIAL BELT is rapidly returning to prominence, as seen in Jose Olivarez' sketches from February 25, 1990 (left), and September 3, 1990 (right). In addition to the Jovian cloudtops, be sure to watch for phenomena among the Galilean satellites (above).

age of more than one event a day. You can also view the normal phenomena of the satellites — their transits, occultations, and eclipses with Jupiter — with the help of the table on page 49.

MARS BIG AND BRIGHT IN THE EVENING

Now that Jupiter has taken center stage, you could easily forget that Mars is still very much worth observing. When the new year begins, the Red Planet is just five weeks past opposition. Although Mars appears smaller and dimmer than it did at opposition, it deserves a serious look because it still presents a large disk.

On January 1, the planet measures 13.8" across, and on the 31st it appears 10.0" in equatorial diameter. Most planetary observers feel that Mars needs to be at least 10" across to show anything more than the grossest details, so this month is your last chance to get a really good view of the planet's surface. To find out what surface markings are visible on Mars, use the chart provided in last month's Through the Eyepiece.

Like Jupiter, Mars is well-placed for viewing in the evening sky this month. It transits — appears due south and is at its highest point in the sky — earlier each night this month. On the 15th, the Red Planet transits around 8 p.m. local time, shortly after the end of evening twilight. And Mars is so far north on the ecliptic that it is *high* in the sky: Its maximum elevation from 40° north latitude is a whopping 72°. That lets you view Mars through nearly the least amount of image-distorting atmosphere as possible.

A SPOTTED SATURN

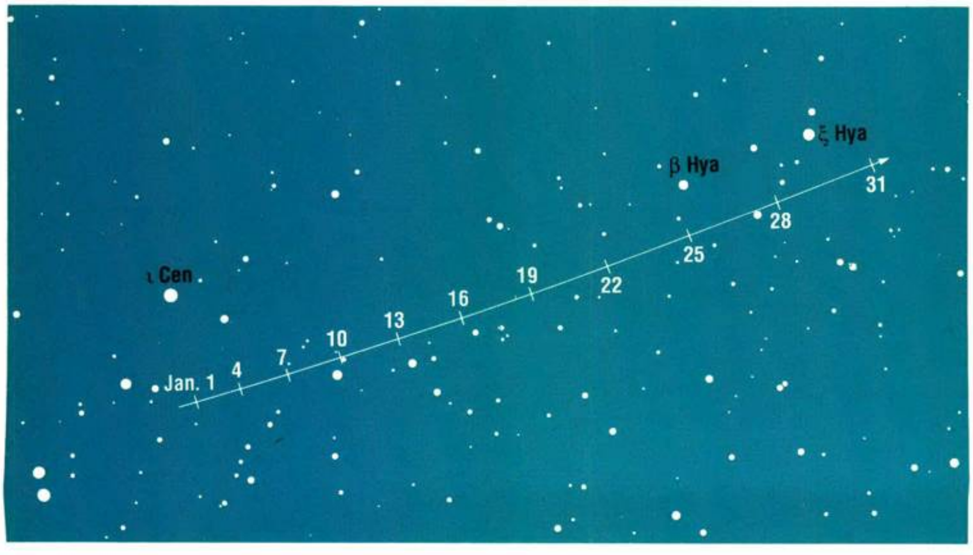
If this were a normal month, I'd devote a sentence or two to informing you that "Saturn is lost in the Sun's glare." However, this month may not be normal at all. The reason for the excitement is the discovery of a new feature in Saturn's atmosphere.

In late September, several observers reported seeing a large white oval in the equatorial region of Saturn's cloudtops. I didn't have a chance to see it until the first week of October, when I viewed Saturn through a 6-inch Maksutov-Cassegrain telescope in moderately good seeing. Immediately upon focusing the telescope, the bright white spot appeared. And it was huge — it subtended fully *one-quarter* of the planet's disk. Since then other white spots have appeared, and the nearby North Equatorial Belt has shown signs of a major disruption.

COORDINATES FOR COMET LEVY

Date	R.A. (2000)	Dec.
Jan. 1	13h19.0m	–40°27'
Jan. 4	13h10.9m	–40°14'
Jan. 7	13h02.1m	–39°58'
Jan. 10	12h52.4m	–39°36'
Jan. 13	12h41.8m	–39°07'
Jan. 16	12h30.4m	–38°31'
Jan. 19	12h18.2m	–37°45'
Jan. 22	12h05.1m	–36°48'
Jan. 25	11h51.3m	–35°38'
Jan. 28	11h36.9m	–34°15'
Jan. 31	11h22.1m	–32°37'

COMET LEVY RETURNS to view for Northern Hemisphere observers in January. The telescopic comet moves from Centaurus into Hydra and appears low in the south early in the morning. Positions are shown at 5 a.m. EST (4 a.m. CST, 3 a.m. MST, and 2 a.m. PST).

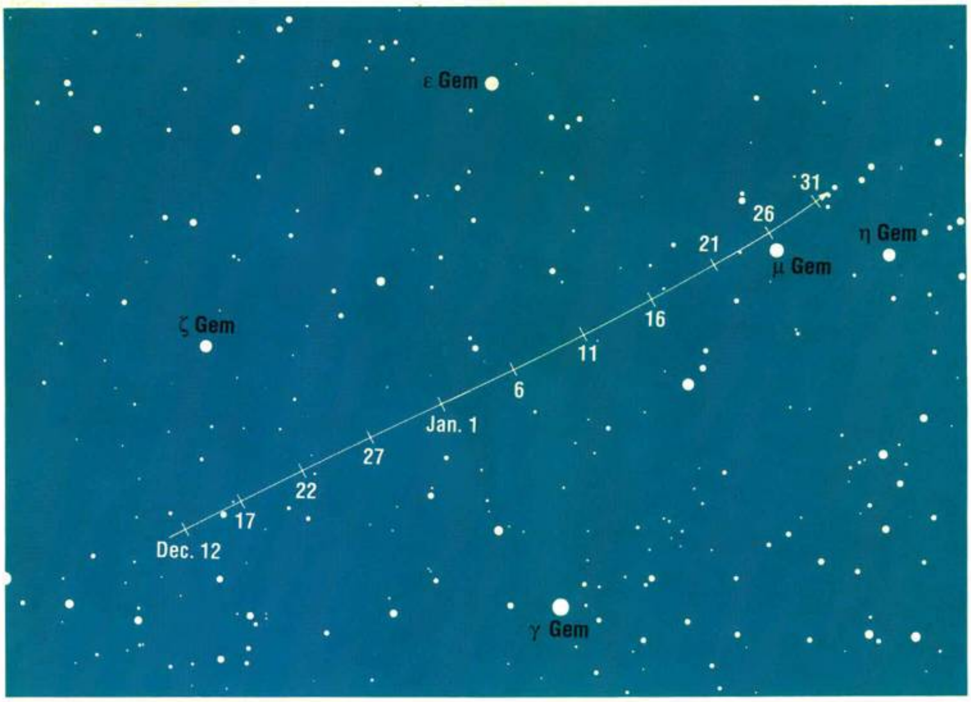


Unfortunately, Saturn reaches conjunction with the Sun on January 18, so you won't be able to observe the planet in January. I mention it now so that if you receive your copy of ASTRONOMY in early to mid-December, you can go out and have a look before Saturn disappears in the solar glare. If you have an evening of good seeing and the high level of activity continues for the next couple of months, you'll be in for a rare treat.

TELESCOPIC PLANETS

Although Saturn escaped being relegated to "solar glare" status by developing an extraordinary spot, Mercury and Venus do so only barely. Mercury is visible throughout January, but this is only a fair apparition for the innermost planet. Your best view of Mercury comes on the morning of greatest elongation, January 14, when it lies 24° west of the Sun and appears 10° above the southeastern horizon 30 minutes before sunrise. Then the –0.2-magnitude planet displays a disk measuring 6.6" in apparent diameter that is 64-percent illuminated.

Venus began an excellent evening apparition last month, but it will take its time before becoming easy to see. By January 31, the brightest planet lies 13° above the southwestern horizon 30 minutes after sunset, though it is easy to see at magnitude –3.9. The planet's 10.8"-diameter disk is 93-percent lit on that day.



ASTEROID 532 HERCULINA is one of the few high-numbered asteroids that is easy to spot in a backyard telescope. The 9th-magnitude point of light can be seen among the stars of Gemini during December and January. Positions are shown at 11 p.m. EST (10 p.m. CST, 9 p.m. MST, and 8 p.m. PST).

COMETS FOR THE TELESCOPE

The first month of the new year brings with it the return of the best comet of 1990. Comet Levy disappeared from view for most Northern Hemisphere observers in late September. For the past few months it has been too far south and too near the Sun to be seen. However, January finds it pulling away from the Sun and heading slightly northward, enough so that it should be visible by around the middle of the month.

At that time Comet Levy lies in northern Centaurus and appears low in the south as twilight begins. By January 31, Levy has moved into southern Hydra and transits about 15° above the southern horizon around 3 a.m. local time. Astronomers predict that the comet will look like a fuzzball and shine at about 8th magnitude. Use the map or table of coordinates on the opposite page to pinpoint Comet Levy's position this month.

ASTEROIDS IN THE EYEPIECE

This is a big month for asteroids, with no fewer than four asteroids reaching opposition at brighter than 10th magnitude. Minor planet 5 Astraea is at opposition on the night of January 6/7 and shines then at magnitude 9.1; 9 Metis is opposite the Sun on January 23 and reaches a magnitude of 8.7; 15 Eunomia also shines at magnitude 8.7 when it reaches opposition late on January 31; and 532 Herculina is a 9.1-magnitude point of light at opposition on New Year's Day.

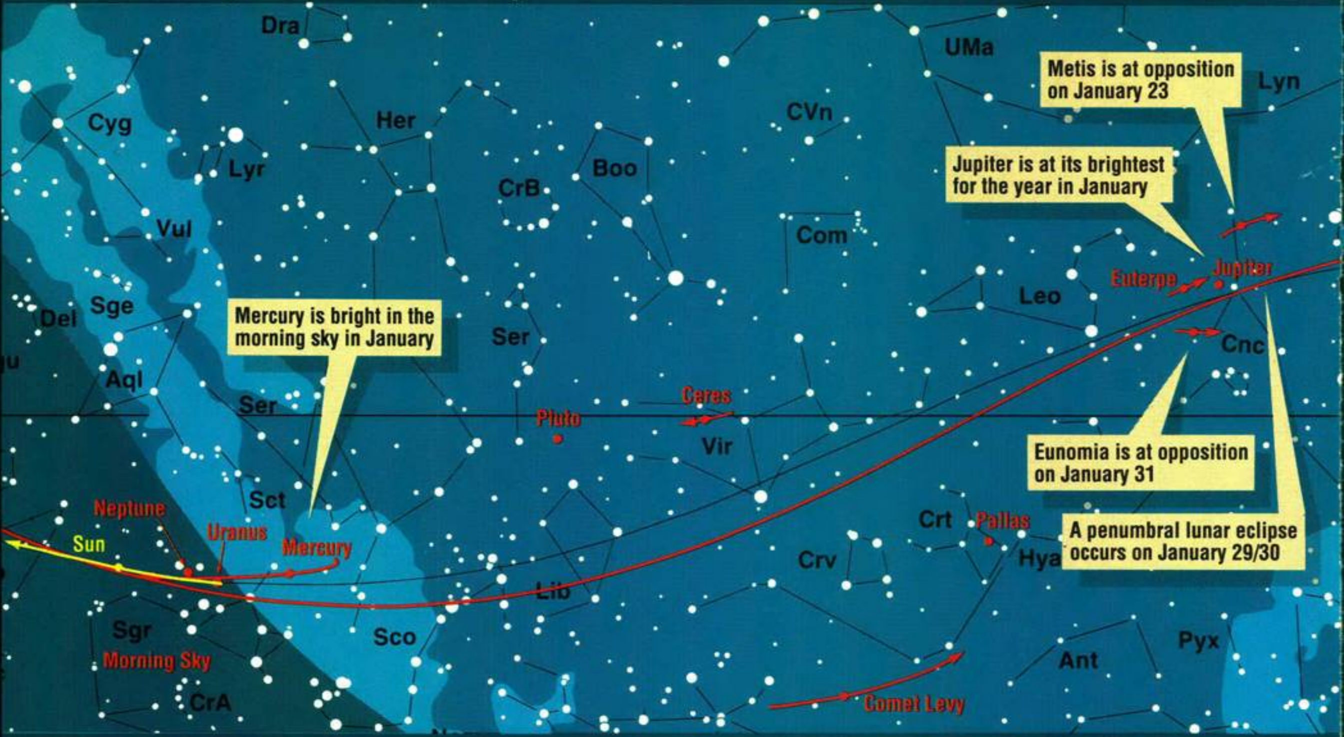
Because asteroids are numbered in order of their discovery, and brighter asteroids are usually found before fainter ones, it is very unusual to see an asteroid with as high a number as Herculina be so bright. To add Herculina to your "life list" of asteroids, use the finder chart or table of coordinates at right to locate its approximate position in Gemini. If you can't tell which 9th-magnitude point of light is Herculina, photograph or sketch the field in your telescope. Then go back a night or two later and do the same thing. The "star" that has changed position between the two observations is Herculina. □

COORDINATES FOR HERCULINA

Date	R.A. (2000)	Dec.
Dec. 12	7h05.2m	17°29'
Dec. 17	7h01.2m	18°00'
Dec. 22	6h56.8m	18°34'
Dec. 27	6h52.0m	19°09'
Jan. 1	6h46.9m	19°45'
Jan. 6	6h41.8m	20°23'
Jan. 11	6h36.7m	21°00'
Jan. 16	6h31.9m	21°37'
Jan. 21	6h27.4m	22°13'
Jan. 26	6h23.5m	22°48'
Jan. 31	6h20.2m	23°21'

Rick Shaffer is a technical group leader at the Jet Propulsion Laboratory in Pasadena, California. He is leader of the data management team on the Ulysses *mission, which was launched successfully on October 6.*

The Solar System January 1991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Comet Levy

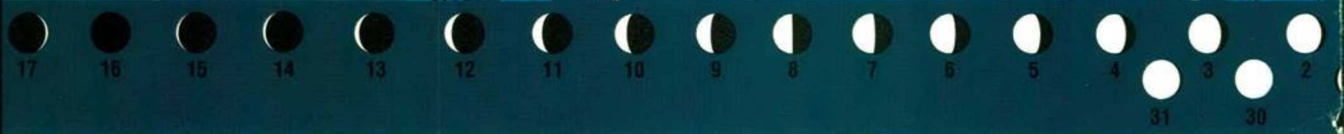
Metis is at opposition on January 23

Jupiter is at its brightest for the year in January

Mercury is bright in the morning sky in January

Eunomia is at opposition on January 31

A penumbral lunar eclipse occurs on January 29/30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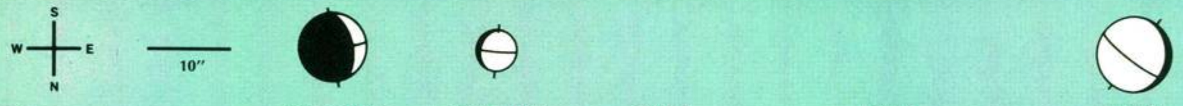
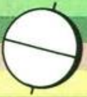
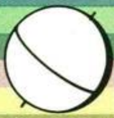


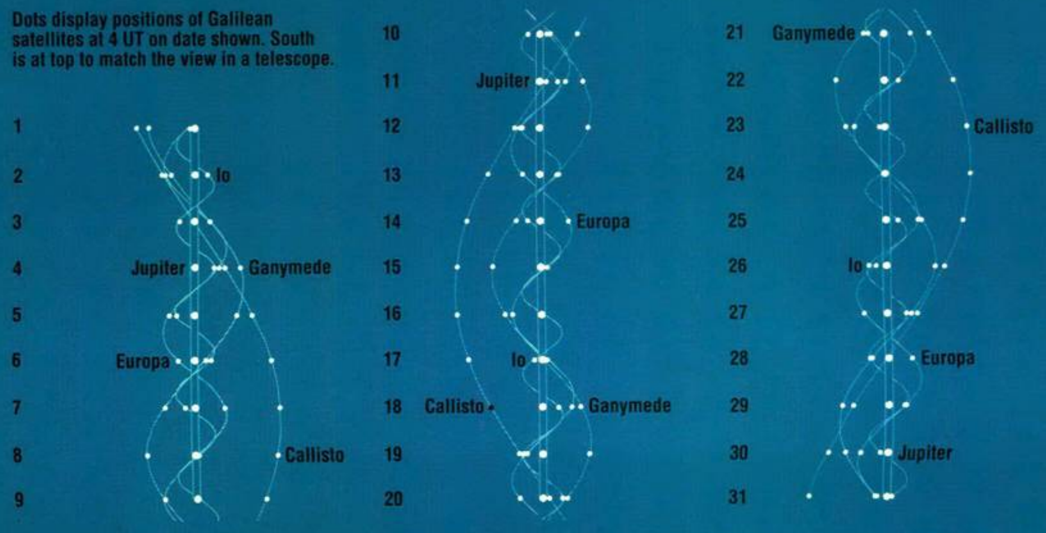
Planet	MERCURY	MERCURY	VENUS	MARS	MARS
Date	January 1	January 31	January 15	January 1	January 31
Magnitude	+1.0	–0.3	–3.9	–1.0	–0.1
Angular Size	9.0"	5.3"	10.5"	13.8"	10.0"
Illumination	21%	85%	95%	95%	91%
Distance (AU) from Earth	0.747	1.259	1.597	0.678	0.931
Distance (AU) from Sun	0.336	0.465	0.728	1.553	1.589
Right Ascension (2000.0)	17h36.3m	19h32.7m	21h01.2m	3h40.2m	4h00.6m
Declination (2000.0)	–20°11'	–22°33'	–18°33'	21°58'	23°01'

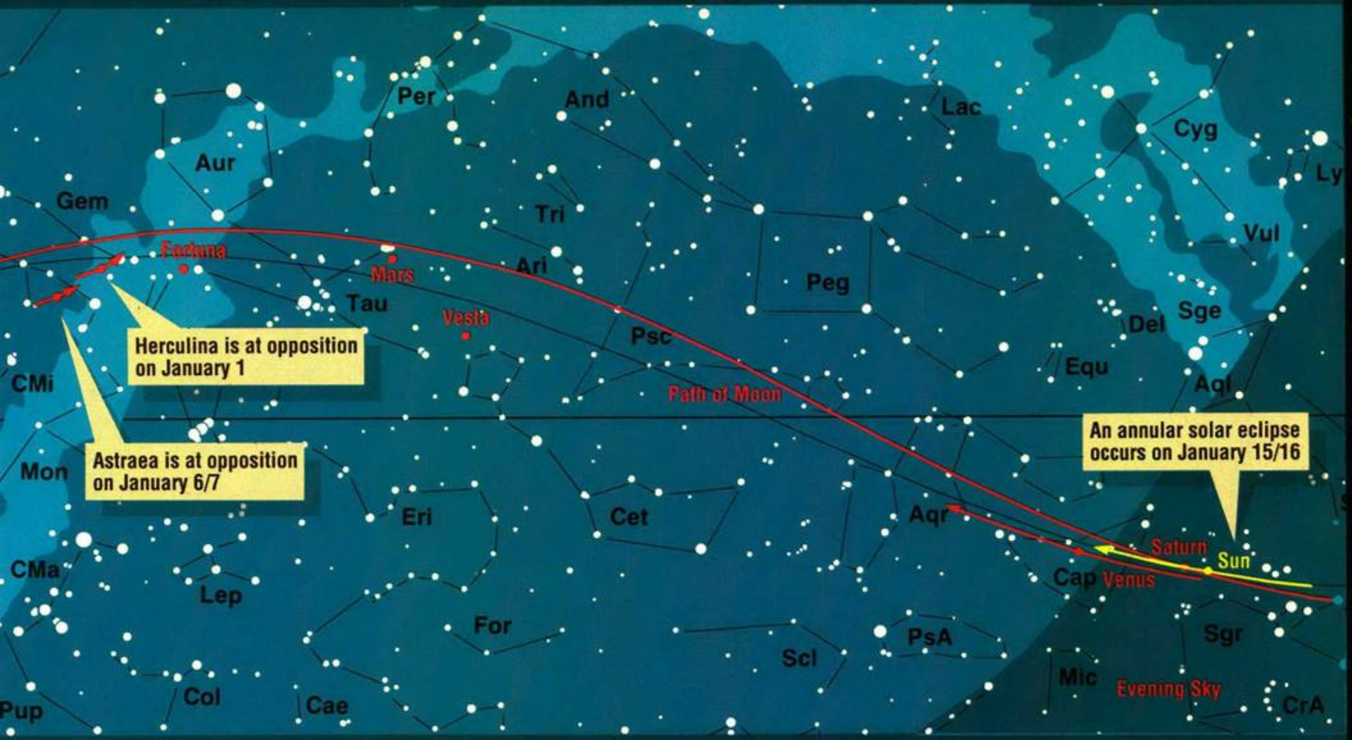




Jupiter's Moons

Dots display positions of Galilean satellites at 4 UT on date shown. South is at top to match the view in a telescope.

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Saturn
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Cap
Venus
For
PsA
Sgr
Scl
Mic
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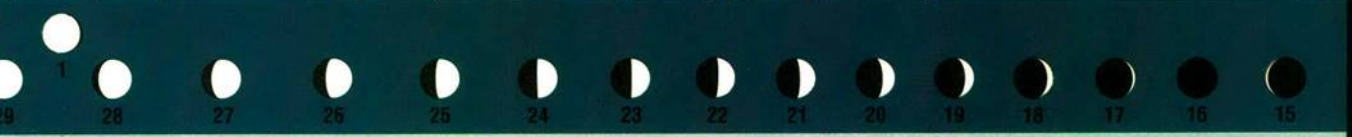
Cae

Herculina is at opposition on January 1

Astraea is at opposition on January 6/7

An annular solar eclipse occurs on January 15/16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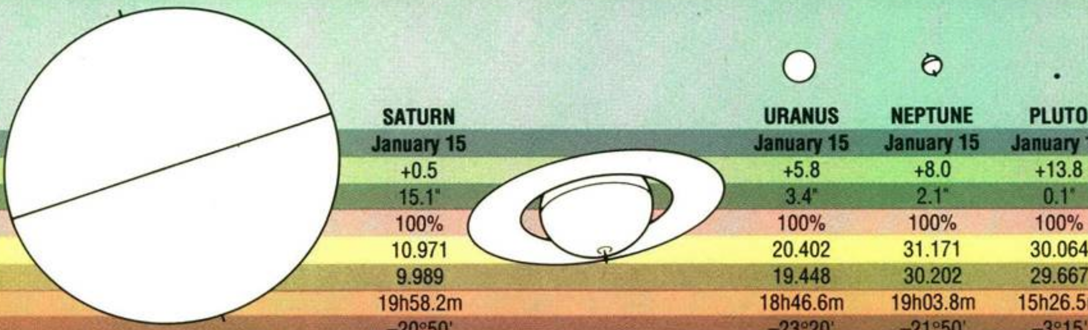
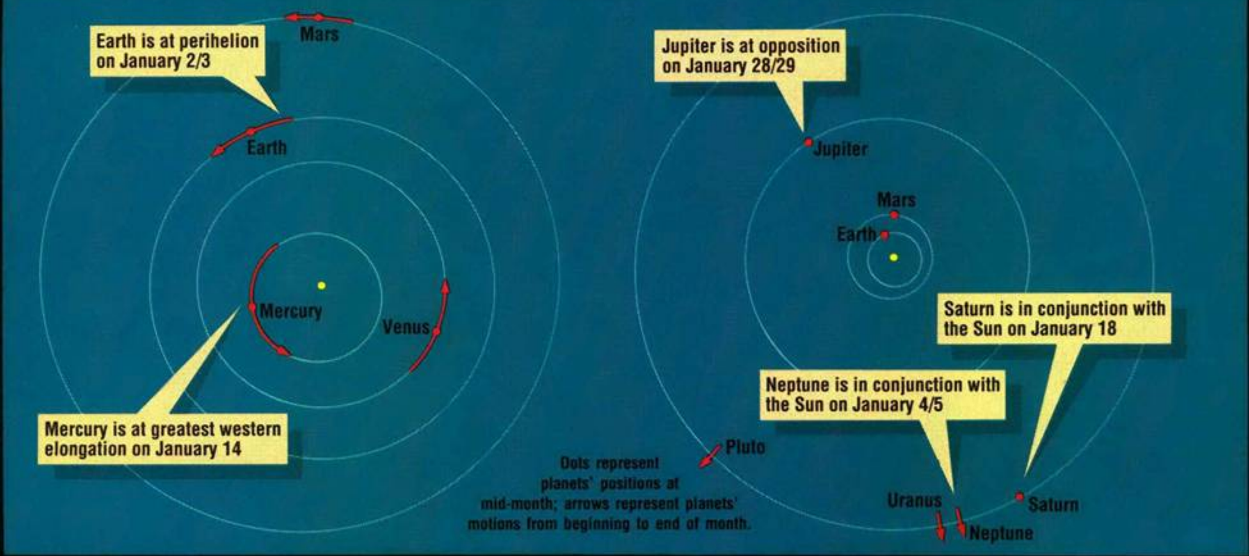


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
January 15	January 15	January 15	January 15	January 15
−2.6	+0.5	+5.8	+8.0	+13.8
45.4"	15.1"	3.4"	2.1"	0.1"
100%	100%	100%	100%	100%
4.334	10.971	20.402	31.171	30.064
5.286	9.989	19.448	30.202	29.667
8h52.8m	19h58.2m	18h46.6m	19h03.8m	15h26.5m
18°18'	−20°50'	−23°20'	−21°50'	−3°15'

The Planets in Their Orbits


Mars
Earth
Mercury
Venus
Jupiter
Mars
Earth
Pluto
Uranus
Saturn
Neptune

Earth is at perihelion on January 2/3

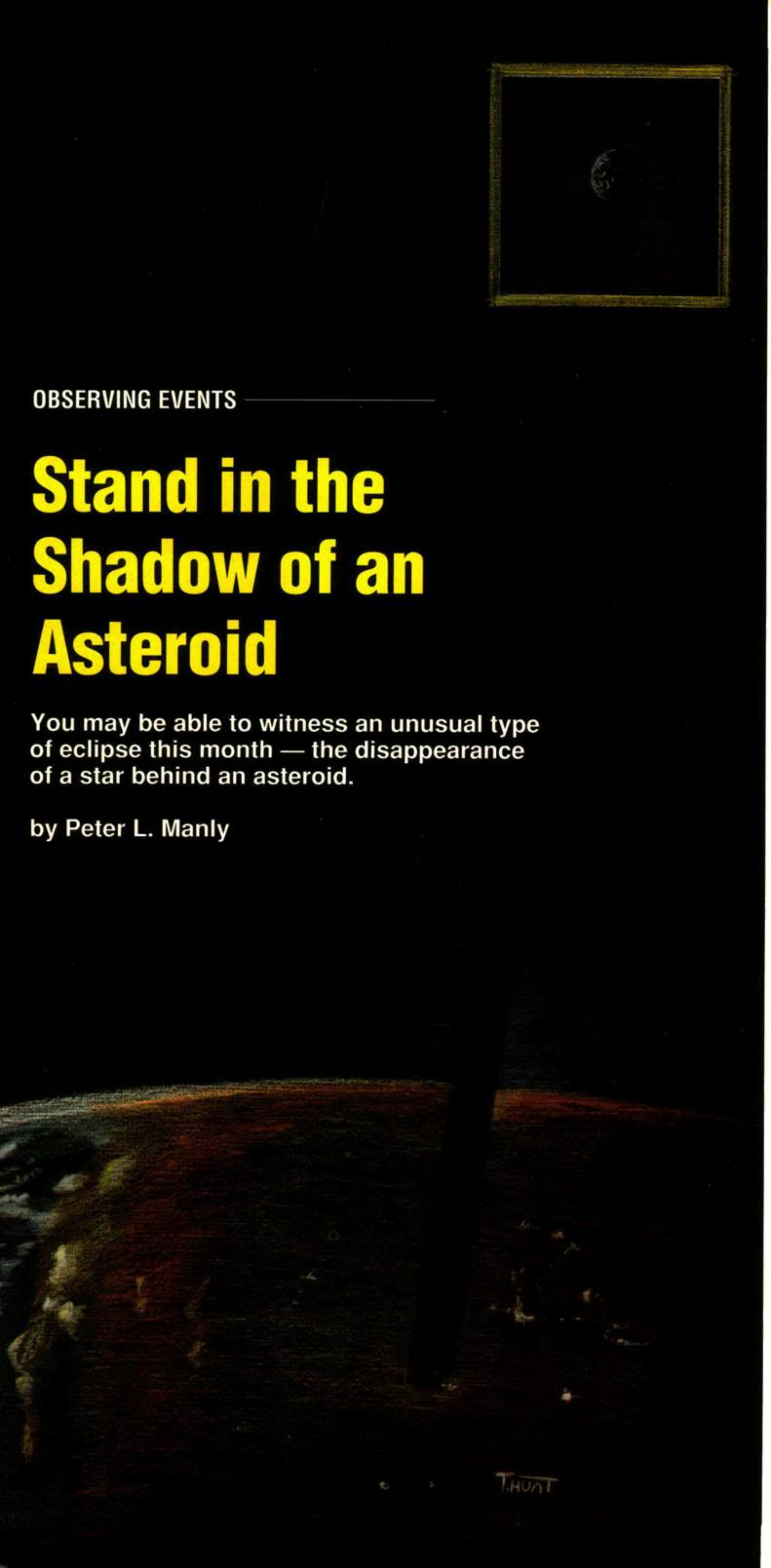
Mercury is at greatest western elongation on January 14

Jupiter is at opposition on January 28/29

Saturn is in conjunction with the Sun on January 18

Neptune is in conjunction with the Sun on January 4/5

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.



OBSERVING EVENTS

Stand in the Shadow of an Asteroid

You may be able to witness an unusual type of eclipse this month — the disappearance of a star behind an asteroid.

by Peter L. Manly

What does it take to measure the size of an asteroid 200 million miles away? An interplanetary probe? A giant mountaintop observatory? Surprise! All it takes is a stopwatch and a 4-inch telescope. Yes, it is possible to reach out and measure the size of an asteroid from your backyard.

The asteroid-measuring method takes advantage of the fact that on rare occasions an asteroid can come between you and a star during what is called an asteroid occultation. At that brief moment you are standing in the shadow of an asteroid. Witnessing such an event is a unique observing experience.

Several dozen occultations occur each year around the world, but from any one location you'd be very lucky to see one a year. However, North American observers get *two* chances this month to see an asteroid occultation: On January 3 the asteroid Vesta will pass in front of a magnitude 7.4 star, and on the night of January 18/19, an asteroid named Kleopatra will hide a magnitude 9.3 star. Through a telescope, both stars are bright and easy to locate.

What You Should See

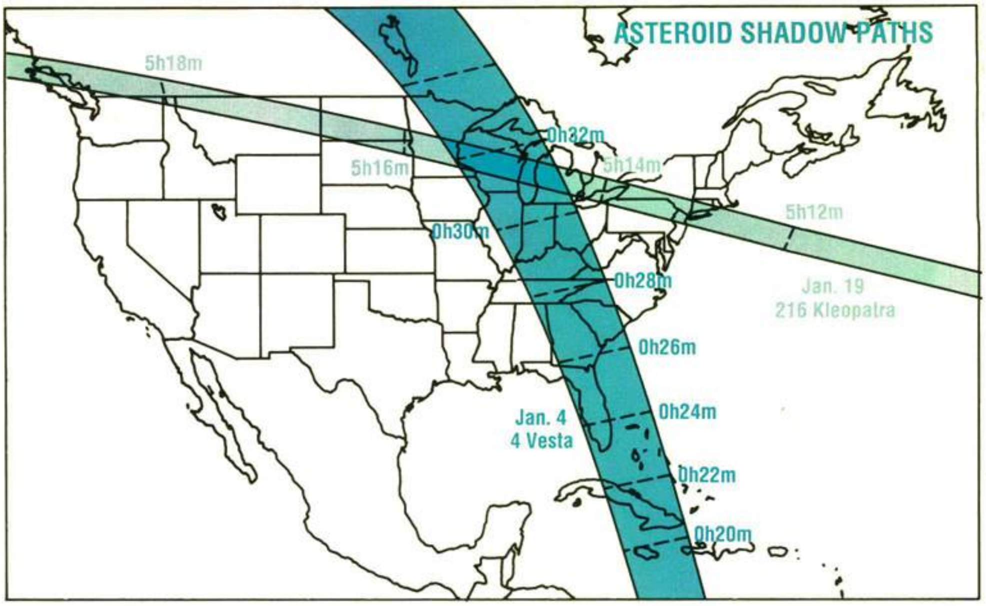
Just prior to an occultation, you see the target star and the asteroid together in the eyepiece, looking like a double star. Then, over several minutes, you see the gap between the two closing with noticeable speed. A few minutes before the occultation, the images of the star and the asteroid merge together into a single point. The asteroid isn't covering the star yet; it's just that they are so close you cannot resolve them into separate images. The actual occultation occurs when the merged image of the star and asteroid suddenly dims.

Although we usually know to within a few seconds when an occultation will take place, experienced observers keep their eyes open for unexpected dips in brightness before and after the main event. These "secondary events" may be caused by companion objects near the asteroid. Whether some asteroids have moons is controversial. It's possible that the visual sightings may have been tricks of the eye or atmosphere. Still, the unexpected can always happen and it is worth being watchful.

The Vesta and Kleopatra Events

The first of this month's occultations is the easiest to observe. Vesta is a magnitude 7.4 asteroid thought to be nearly spherical in shape and

TWO ASTEROID SHADOWS crisscross North America this month. Vesta's shadow travels from south to north, while Kleopatra's travels east to west. The occultation times indicated are universal time. Subtract 5 hours for Eastern, 6 hours for Central, 7 for Mountain, and 8 for Pacific Times. Times and path location may change at the last minute. Diagram by Patti Keipe based on maps by David Dunham, IOTA.



between 327 and 336 miles in diameter. It has rarely been seen occulting a star. Vesta is an extremely bright asteroid, so it usually outshines any star it encounters. On January 3 the star it occults will also have a magnitude of 7.4, which makes this all the more rare an event.

The best estimate for the time of the event as ASTRONOMY went to press was about 7:26 p.m. Eastern Standard Time (about 6:32 p.m. in the Central Time zone), with the exact time depending on your location along the path. If you are on the center line of the shadow path, the occultation may last as long as 145 seconds. If you are at the edge of the shadow, then the merged images may dim for only a second or two.

However, even if you are not on the path, watch anyway. A hypothetical moon of Vesta could be up to 3,000 miles from the asteroid and still be gravitationally bound to Vesta. At Vesta's distance and rate of motion across the sky, a moon can precede or trail Vesta by as much as 21 minutes. Therefore, an occultation from such an object could occur any time from 21 minutes before the main event to 21 minutes after. As a practical matter, of course, you won't be able to stare into an eyepiece non-stop for 42 minutes. One solution is to observe with a friend who also has a telescope. When one observer looks away, the other continues monitoring.

A second occultation occurs on the evening of January 18/19. The magnitude 11.0 asteroid Kleopatra will pass in front of a magnitude 9.1 star at about 12:14 a.m. Eastern Time (January 19) or 11:16 p.m. Central Time (January 18). In small telescopes, the 1.7 magnitude drop in brightness may make the star seem to disappear altogether. Since this asteroid is estimated to be only 82 miles in diameter, the maximum length of occultation can be only about 13 seconds.

It's All in the Timing

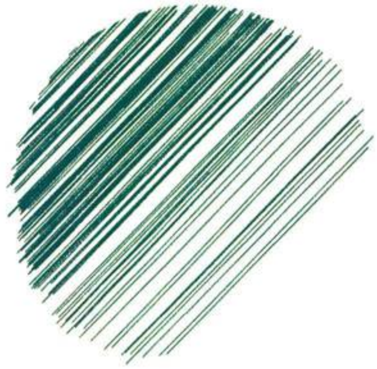
Knowing precisely when the star disappears and reappears as well as the asteroid's distance from Earth and orbital motion tells us the size of the asteroid. In addition, observers stationed at scattered locations in the shadow path will see the star pass behind a different slice of the asteroid. Combining their observations, a picture of the asteroid's shape emerges.

To record your observation, all you need is a small telescope, a tape recorder, and a shortwave radio capable of receiving WWV or WWVH. These stations broadcast accurate time from the National Bureau of Standards on frequencies of 2.5 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz. You can also use CHU at 7.335 MHz and 14.67 MHz.

Here's what you do: watch the star while recording your voice on the tape recorder with the WWV radio playing in the background. When the star disappears and reappears, shout "Out!" and "In!" By replaying the tape later, you can estimate the time of the events to an accuracy of about a quarter of a second. Remember that when observing a sudden or unexpected event, you should subtract about 1/4 to 1/2 second from the time on the tape to account for your reaction time.

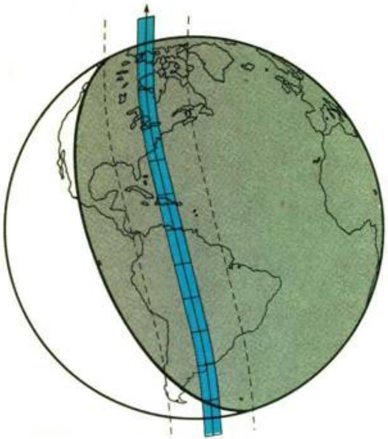
To avoid last-minute problems, you should go out several days before the event and identify the star of interest from the finder charts on pages 56 and 57. On the night of the event it's a good idea to have spare warm batteries on hand for both the radio and tape recorder since cold weather can play havoc with battery strength.

If you see a momentary wink-out, note it on the tape but don't ramble on describing it in detail because you might miss the next event. If you don't have a tape recorder, you can gain data of lesser value (but still important) by using a stopwatch. For this method, you record the duration of the occultation but not the absolute time of the start and end of the event. If you don't have a WWV radio, you can call the U.S. Naval Observatory at (900) 410-8463 or the National Bureau of Standards and Technology in Colorado at (303) 499-7111 and calibrate your watch. These are toll calls. They connect you via land lines that do not have a satellite delay. Don't depend on radio stations and other commercial time recordings — they are accurate to only five or ten seconds.



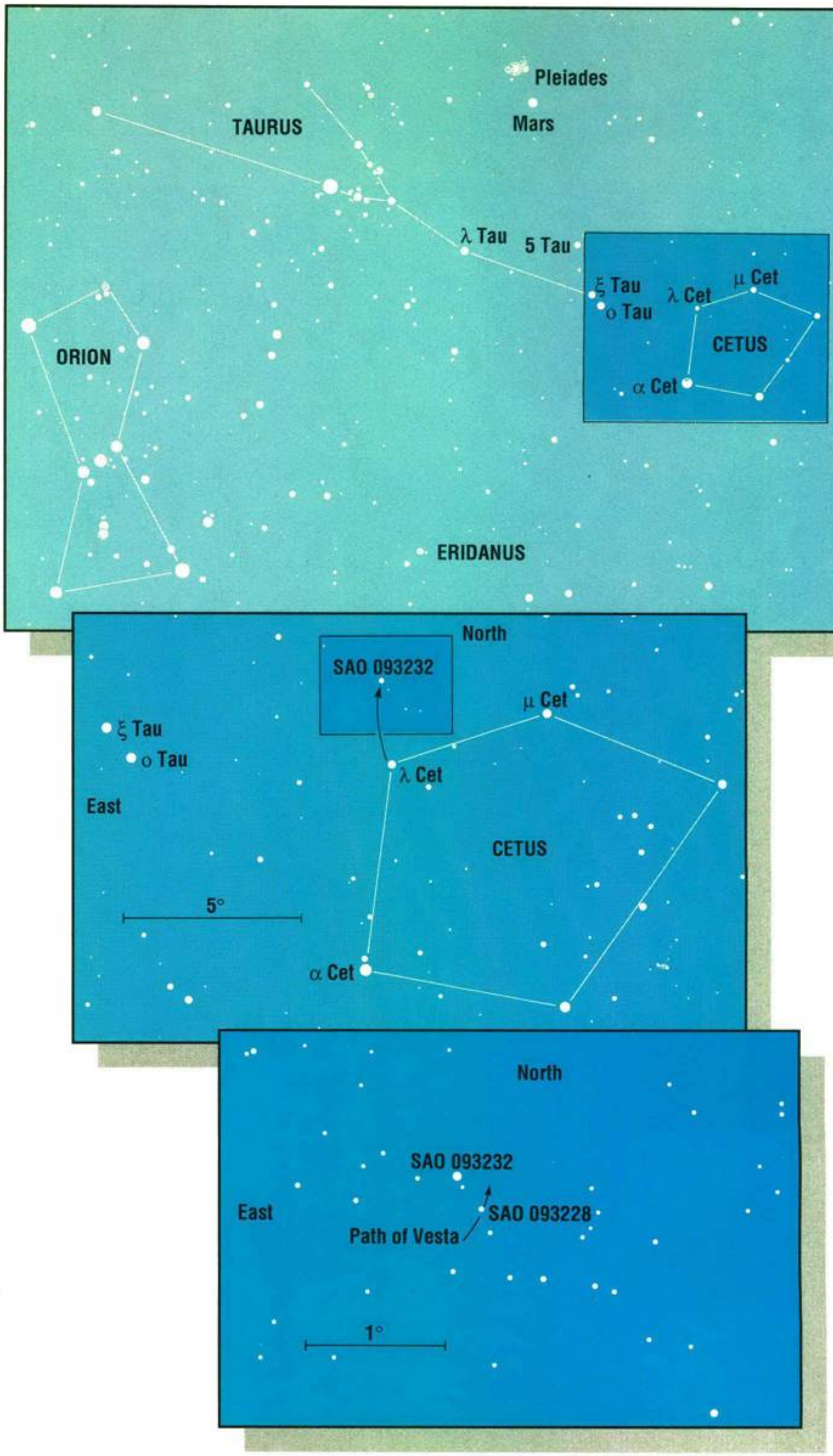
SLICES ACROSS AN ASTEROID are created when observers from different locations combine their timings. The result is an actual picture of the size and shape of the asteroid. This chart shows the raw observations of the Pallas occultation of May 1983. Diagram courtesy David Dunham, IOTA.

If you want to get high-tech, you



VESTA'S SHADOW sweeps across South America and eastern North America as these parts of the world rotate into night. Diagram courtesy Jim Stamm, IOTA.

can try using a video camera. Since the star and asteroid for the Vesta event are fairly bright, a 16-inch aperture telescope and one of the more sensitive CCD home video cameras *may* be able to record the occultation. If you record WWV on the audio track, you can examine the tape later to obtain event times to 1/30-second accuracy. This would be an excellent way to record secondary occultations objectively since a TV camera can watch the star tirelessly for many minutes.



TO FIND VESTA look southwest of Mars and the Pleiades. Use the stars 5 Tauri, Xi Tauri, and Omicron Tauri to guide you into the area. The magnitude 6.0 star SAO 093232 is in the same field as the target star and Vesta. Maps by Patti Keipe based on maps by Jim Stamm, IOTA.

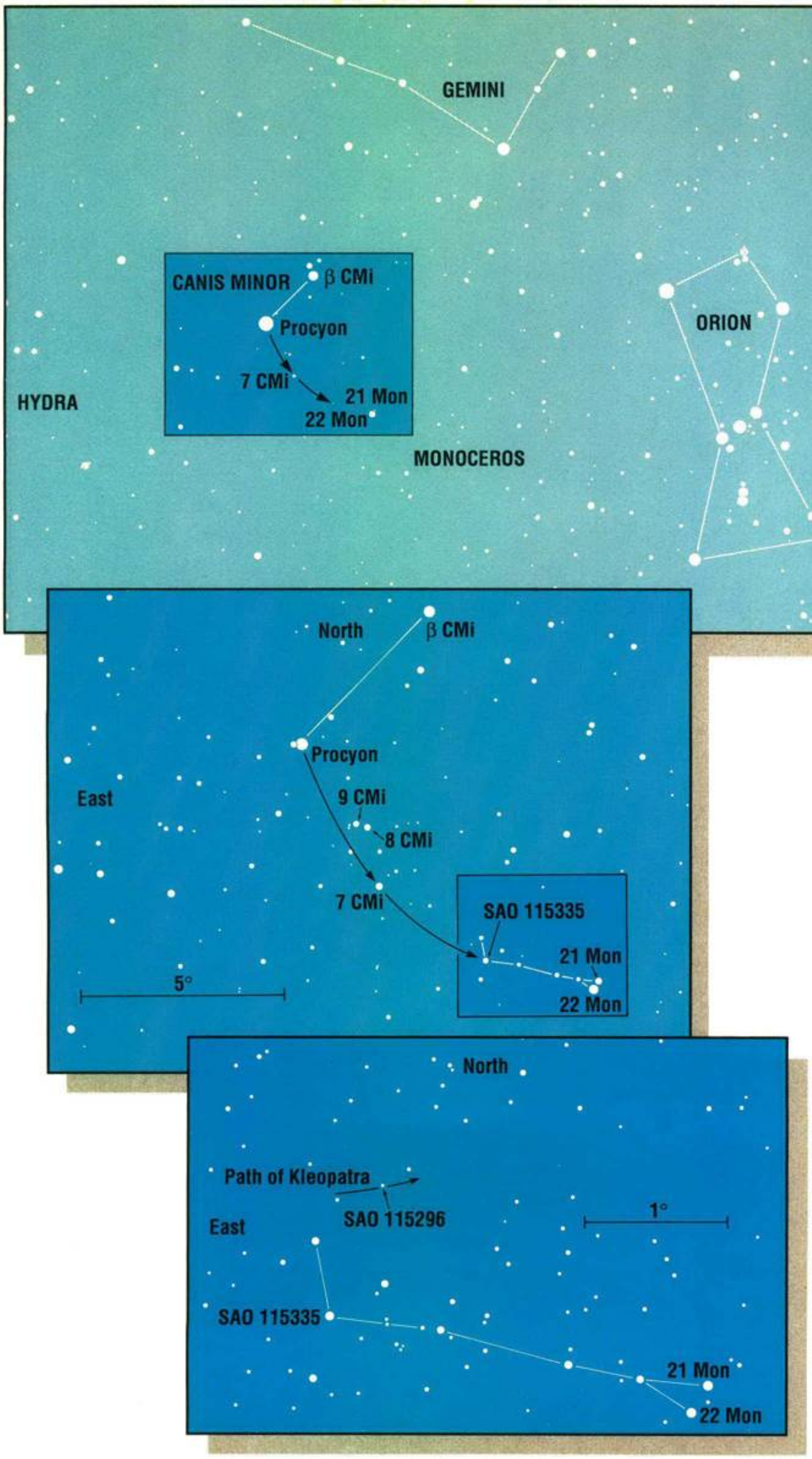
Who You Gonna Call?

Once you have made your observation, record the aperture, focal length, optical type, and magnification of your telescope. Record the sky conditions, seeing, transparency, and any unusual circumstances such as thin, patchy clouds that might have interfered with your observation. Note the time you started observing continuously and when you stopped. Include any brief periods when you looked away from the eyepiece. All of this information might also be recorded on your tape so that you have a permanent record of your observation. After the observation, use the tape recording to determine the time of the event. You'll also need to know the exact latitude, longitude, and altitude of your observing site. These can be found on topographical maps of your area.

Now you need to send this hard-won data to someone who will combine your observations with all the others received. That "someone" is IOTA, the International Occultation Timing Association. Write to IOTA member Jim Stamm at 11781 N. Joi Drive, Tucson, AZ 85737.

Report your observation even if the shadow path missed you completely. While the data may seem uninteresting, the true diameter of the asteroid isn't known until a grazing chord is recorded at one site and a miss is recorded at an adjacent site. In addition, a miss records where possible companion objects *aren't* located.

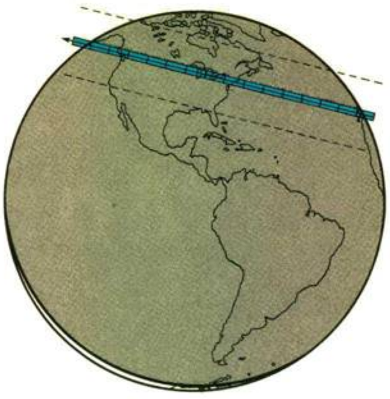
Prior to the events, you'll also need to keep in touch with IOTA for last-minute updates of the occultation predictions. Although we've indicated shadow paths and times on the map on page 55, these could change. *A few* days before each event, the star and asteroid will be close enough that they can be pho-



TO FIND KLEOPATRA, look east of Orion to the area of Canis Minor and Monoceros. Use the pair of stars 21 and 22 Monocerotis to bring you to SAO 115335. This magnitude 6.0 star is about 1° southeast of the target star. Maps by Patti Keipe based on maps by Jim Stamm, IOTA.

tographed on the same plate and their relative positions measured much more precisely. As a result, the times shown on the chart may change by a few minutes and the predicted path of the shadow may shift to one side or the other. In the case of Vesta, this implies that the shadow may cross the midwest or fall in the Atlantic Ocean.

You can get the updated shadow path information by calling the nearest IOTA recording a few days before the event. Call either (301) 474-4945 (Maryland) or (708) 259-2376 (Chicago).



KLEOPATRA'S SHADOW skims across North America during the middle of the night. Diagram courtesy Jim Stamm, IOTA.

Go as a Group

Both occultations this month provide an excellent opportunity for astronomy clubs to arrange exciting and rewarding activities for their members. For the Vesta occultation in particular, IOTA will be coordinating hundreds of observers all over eastern North America. The project will be similar to the 1983 monitoring of an occultation by the asteroid 2 Pallas.

If there are many observers in a large metropolitan area, they should fan out across the path of the shadow. This will ensure wider coverage and close the gaps that a companion object's shadow could slip through. You can get a list of regional coordinators through IOTA. The object is not to have everybody observing on the same line along the shadow path. Observing asteroid occultations is unlike observing lunar graze occultations or eclipse measurements in that you needn't go to heroic efforts to be at some precise position so many meters from the nearest observer. You simply need to know where you observed from to a high accuracy.

One word of caution, however — whether you observe with a group or on your own, asteroid occultations can be addictive. They can be great fun, providing a unique opportunity to reach out across the solar system from your backyard. While both occultations this month are brief, the experience of seeing such a rare event lasts a lifetime. ☐

Peter L. Manly is an amateur astronomer living in Tempe, Arizona, who operates a business consulting on astronomical instrumentation. His last article for ASTRONOMY was "Beneath the Neon Lights" in June 1990.

Watch Jupiter's Moons Play Tag

A stunning series of mutual eclipses and occultations will keep backyard observers busy and happy throughout the next several months.

by John E. Westfall

To see a truly spectacular eclipse of the Sun, be on Jupiter's moon Callisto on April 29, 1991. The tiny disk of the Sun will be covered — by our fellow satellite Europa — in only 7 minutes. Totality will be stunning. For three-and-a-half minutes Europa will block the Sun's glare and you will be able to see the solar corona, as well as six planets clustered within 11° of the Sun. Six degrees east of the Sun is the thin sliver of Jupiter itself, looming over 4° across. West of the Sun lie Mars, Venus, Mercury, Saturn, and Earth, the last a 1st-magnitude, blue-green point of light. Had you visited Callisto 17 days earlier, you would have seen Earth blocked from view for up to half an hour by Jupiter's largest moon, Ganymede.

So Many Events, So Little Time

Although eclipse cruises do not yet reach Jupiter, you can see these "mutual events" yourself, albeit from a different perspective. They happen every six years, near the times when the Sun and Earth pass through the equatorial plane of Jupiter. This year the Sun passes through that plane on May 11, while Earth follows suit on July 17. Because Jupiter's four Galilean satellites orbit the giant planet nearly in the plane of Jupiter's equator, one can cast a shadow on another, causing a *mutual eclipse*. Likewise, one satellite can come between another and Earth, resulting in a *mutual occultation*. Between November 13, 1990, and April 12, 1992, there are 346 mutual events — 153 occultations and 193 eclipses.

Each mutual event is unique. There are 24 possible combinations of eclipses and occultations among the four Galilean satellites. Some of the events are partial, when one satellite or its shadow just grazes another satellite. A total event happens when one satellite blocks or eclipses the entire disk of another. And finally, an annular event happens when the nearer satellite appears entirely within the disk of the second or when its shadow appears entirely contained within the disk of the eclipsed satellite. The graph on page 61 shows the span of dates during which each type of event takes place.

Other significant differences between satellite events are when they occur, so the regions on Earth where they are visible can be determined; how long they last, which depends on the relative motions and the sizes of the two satellites; and how "deep" they are (the maximum amount of dimming). To the eye, a light drop of less than 20 percent is very difficult to perceive, one of 20 to 40 percent requires careful comparison with other satellites to be detected, a drop of 40 to 95 percent is quite obvious, and fadings of over 95 percent can make a satellite disappear! The number of events that fit each of these categories is summarized below.

Mutual Events Overview

	Proportion of Light Lost				
Type of Event	**0-19%**	**20-39%**	**40-94%**	**95-98%**	**Sum**
Occultations	81	61	11	0	153
Eclipses	78	36	71	8	193
Total	159	97	82	8	346

The Best of the Best

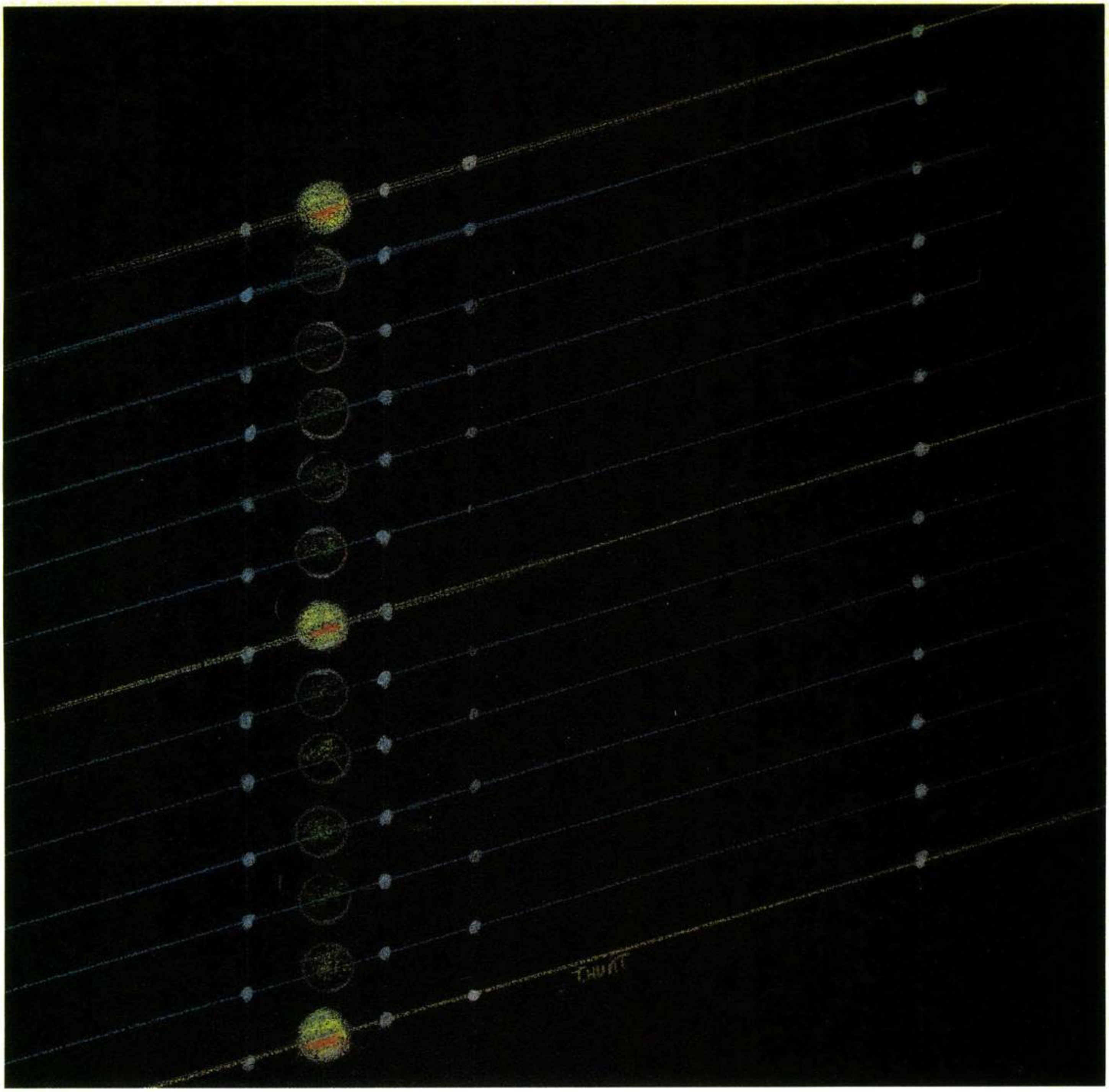
The table on pages 62 and 63 lists the mutual events that occur between December 1990 and May 1991. (Events occurring after May 1991 will be treated in a later issue.) Those events in boldface can be seen from all or part of the contiguous United States; some of these are especially interesting. Tastes differ, but I particularly recommend the following events for North American observers:

On New Year's Day, Europa occults Io twice in 4 hours. But January 8 shapes up as one of the more interesting days during the entire series of events. First, Europa occults Io while the two of them appear directly in front of Jupiter. Later that day, Europa eclipses Io twice in 4 hours, and then occults it again 2 hours after that. On January 9, Europa eclipses Ganymede and occults it 2 hours later. On the 12th, Europa eclipses Io and occults it 1 hour later.

In many ways, the most spectacular event occurs on January 15. During prime observing hours from North America, Europa eclipses Io while the two are in front of Jupiter. Because this is an eclipse, not only will Io fade (dimming by 62 percent), but also the shadows of the two satellites on the Jovian cloudtops will merge into one!

On January 16, Europa eclipses Ganymede and occults it 2 hours later. On the 19th, Europa eclipses Io and occults it a half hour later. On January 22, Europa occults Io twice in 3 hours, with the last occultation merging with an eclipse. On January 23, there is a lengthy occultation of Ganymede by Europa. And on the 26th, there is an overlapping eclipse and occultation of Io by Europa.

On February 2, 9, 13, and 20, Europa occults Io and an eclipse begins less than an hour after the occultation ends. On February 22, there is a lengthy occultation of Callisto by Ganymede. On the 27th, Europa oc-



EUROPA IS LOST IN GANYMEDE'S SHADOW during a near total eclipse on the night of April 15/16. Eyepiece views are shown during the 10-minute interval around the time of maximum eclipse (5h27m UT on the 16th). Ganymede is the moon immediately to the right of Jupiter, while Europa is to the right of Ganymede. Illustration by Tom Hunt.

cults Io and an eclipse begins 64 minutes after the occultation ends.

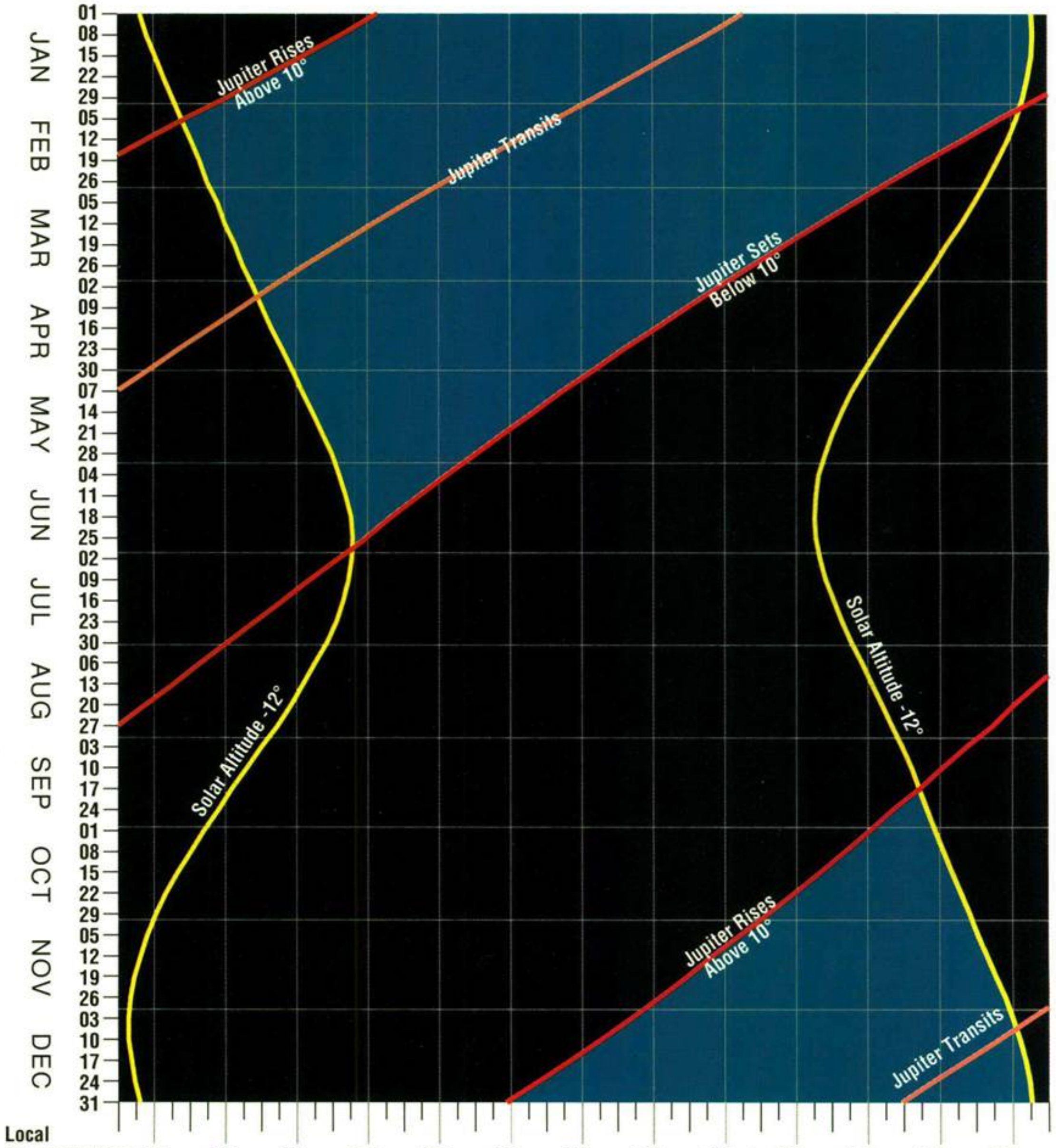
March brings four more occultations of Io by Europa with eclipses beginning between 1 and 2 hours after the occultation ends. They occur on March 6, 13, 24, and 31. On April 7, Europa occults Io followed by an eclipse that begins 109 minutes after the occultation ends. On April 9, Ganymede eclipses Europa with a 78% light loss. Ganymede eclipses Europa again on April 16 with a 97% light loss. And on April 26, Io eclipses Europa with an 80% light loss.

There are three substantial eclipses in May. On the 9th, Callisto eclipses Io with a 78% light loss. On May 14, Io eclipses Europa with a 75% light loss. And on May 22 and 29, Ganymede eclipses Io, with the first resulting in an 88% light loss and the second a 98% light loss.

Observing an Event

What you will see of a mutual event depends on your observing skills, the size and quality of your telescope, and the atmospheric seeing. In planning an observation, first consult the diagram on page 60 to be sure that Jupiter is visible in a dark sky at the time of the event. Match your time zone and the universal time of the event to the date shown on the graph. (Add 4 minutes for every degree that you are east of your time zone's standard meridian, and subtract 4 minutes for every de-

JUPITER VIEWING SCHEDULE: 1991



Local Standard Time	18h	19h	20h	21h	22h	23h	00h	01h	02h	03h	04h	05h	06h
U. T. by U.S. Time Zone: Eastern	23h	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h
Central	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h
Mountain	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h
Pacific	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h

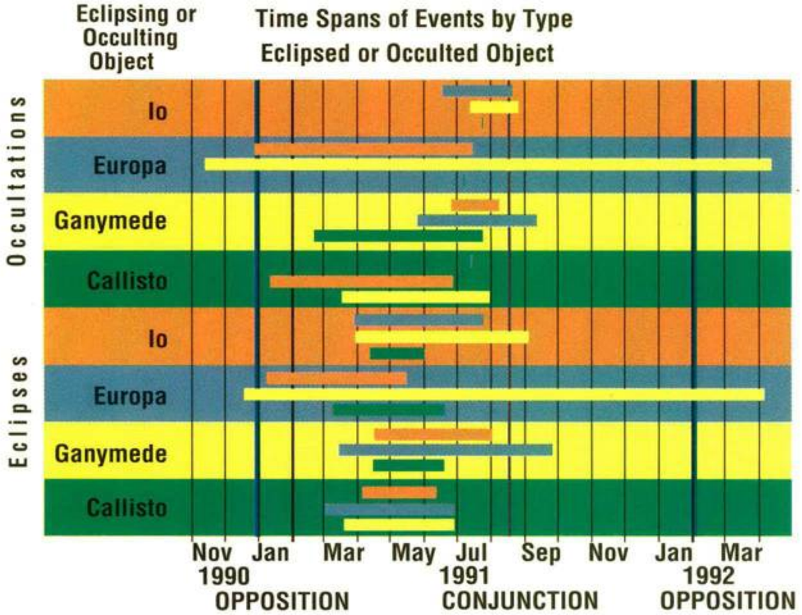
YOU CAN SEE A MUTUAL EVENT whenever Jupiter is visible in a dark sky. Match the *universal time* of an event to the UT in your time zone at the bottom of the diagram. The event is visible if the vertical line above that time intersects a horizontal line corresponding to the date in the area shaded in blue.

gree you are to the west of the standard meridian.) If the event lies in the area of the diagram shaded in blue, it will be visible.

Next, use a chart showing the positions of the Galilean satellites (such a diagram appears on the final spread of the "Sky Almanac" section of ASTRONOMY each month) to locate the satellites at that time. Although you'll have no trouble telling which satellite will be involved in an occultation, you need to pinpoint an eclipsed satellite ahead of time or risk missing the event.

With a telescope less than about 6

MUTUAL EVENTS OF THE GALILEAN SATELLITES, 1990-1992



THE "WINDOW OF OPPORTUNITY" during which mutual eclipses and occultations occur varies for each type of event. For example, eclipses of Ganymede by Europa occur between mid-December 1990 and early April 1992. Each satellite is color-coded to aid in its identification.

inches in aperture, or with any telescope under mediocre seeing conditions, each satellite will appear as an unresolved point of light. Nonetheless, use a fairly high magnification (up to 30x per inch of aperture) so that the separations of the two "stars" can be seen clearly. In a mutual occultation, the two moons will slowly approach each other and then merge into a single elongated image equal in brightness to the two satellites combined. In the next stage, this bright elongated image becomes fainter and more circular, although the amount of dimming may not be obvious. After that, these two stages happen in reverse order.

As the two satellites approach and then recede from one another, you can judge their apparent separation in terms of Jupiter's diameter. You could record their spacing in units of Jovian diameters every few minutes, although it would be more interesting to draw a series of eyepiece views of both bodies in relation to each other.

During a mutual eclipse, only one satellite is of interest — the one being eclipsed. To estimate the eclipsed satellite's magnitude, compare its brightness to that of the unaffected satellite. As a standard, use the apparent visual magnitudes of the four satellites at an average opposition: Io is magnitude 5.0, Europa is 5.3, Ganymede, 4.6, and Callisto, 5.6.

With a clock-driven telescope, you can record an eclipse or occultation with a series of photographs. A series of good photos that shows two satellites merging, or one satellite fading, can be very dramatic. Before you try this technique, however, practice photographing the Galilean satellites with the same film and optical system you will use for the big event. Exposures of a few seconds should capture these bodies with no problem.

Getting a Better View

To make out the true nature of these events, you'll need a larger telescope with good optics, sharp eyes, and steady seeing. Under these conditions, you'll see the satellites as disks rather than as points. Ideally, you should also be able to see the difference in size between the small disks of Io and Europa and the larger ones of Ganymede and Callisto.

During a mutual occultation you'll be able to see the disk of the nearer satellite as it moves across the disk of the more distant one. This will be particularly clear if one of the satellites is Callisto, because its reflectivity, or albedo, is much lower than those of the other three moons.

Likewise, in a mutual eclipse you should see the shadow of the eclipsing satellite encroach upon the disk of the eclipsed satellite. If it is an annular eclipse, you may even see the distinctive bulls-eye shape of the shadow!

A careful series of drawings will be even more interesting if you're able to resolve the satellites' disks. But many of these events progress so rapidly that you may need to make the drawings at frequent intervals, perhaps as often as one a minute! Photographing an event with a larger telescope should be easier than with a smaller scope, because the exposure times are shorter, but you'll need a very large telescope to resolve the disks of the satellites.

Finally, you can videotape mutual events if you use an 8-inch or larger telescope. As with photography, practice beforehand to make sure that your setup works. If you record WWV shortwave time signals (available at 5, 10, 15, and 20 MHz) on the tape's soundtrack, your observations could have important scientific value. See "Let Us Hear from You" below for more details on this.

"Serious" Observing

Most people who have observed earlier "cycles" of these mutual events agree that they are well-worth watching for their own sake. But many advanced amateur observers also enjoy making precise measurements of the mutual events, measurements that can help astronomers learn more about the satellites' orbits and even their surface compositions.

Serious observations of a mutual event require making frequent and carefully timed measurements of the satellites' brightnesses with a photoelectric photometer. You'll need to take readings at 1- to 2-second intervals for the duration of the event, with each reading timed to an accuracy of 0.1 second if possible. V (visual) filters are most often used. Later on, the change in brightness with time can be analyzed to determine the satellite's orbital longitude, which is gleaned from the time of mid-event, and its orbital latitude, which is estimated by the maximum light loss measured.

Photoelectric measurements are useful for eclipses and occultations when the sky is dark and the affected satellite is far enough from Jupiter that scattered light is not severe. (In the list of events, the entries in blue take place under conditions that are poor for photoelectric photometry.)

The series of occultations of Io by Europa gives a rare opportunity to map the volcanically active surface of

SCHEDULE OF MUTUAL EVENTS

UT Date	Event	Type of Event	UT Begin	UT End	DL	R
Dec. 04	**2 occ. 3**	**A**	**1148**	**1200**	**23**	**09**
Dec. 11	2 occ. 3	A	1510	1524	23	09
Dec. 18	2 ecl. 3	P	1512	1515	00	11
Dec. 18	2 occ. 3	A	1833	1848	23	09
Dec. 25	2 ecl. 3	P	1853	1904	03	11
Dec. 25	2 occ. 3	A	2159	2216	23	09
Dec. 28	2 occ. 1	P	1920	2022	03	04
Jan. 01	**2 occ. 1**	**P**	**0613**	**0648**	**15**	**03**
Jan. 01	**2 occ. 1**	**P**	**1022**	**1051**	**09**	**05**
Jan. 01	2 ecl. 3	P	2245	2301	13	10
Jan. 02	**2 occ. 3**	**A**	**0130**	**0150**	**23**	**09**
Jan. 04	2 occ. 1	P	1751	1820	21	02
Jan. 05	2 occ. 1	P	0010	0028	10	06
Jan. 07	2 occ. 1	P	1949	1952	00	06
Jan. 08	**2 occ. 1**	**P**	**0547**	**0606**	**34**	**01**
Jan. 08	**2 ecl. 1**	**A**	**0716**	**0800**	**71**	**02**
Jan. 08	**2 ecl. 1**	**A**	**1136**	**1218**	**68**	**05**
Jan. 08	**2 occ. 1**	**P**	**1337**	**1352**	**12**	**06**
Jan. 09	**2 ecl. 3**	**P**	**0252**	**0314**	**24**	**10**
Jan. 09	**2 occ. 3**	**A**	**0513**	**0538**	**23**	**09**
Jan. 10	4 occ. 2	P	1548	1558	62	09
Jan. 11	**2 occ. 1**	**P**	**0906**	**0911**	**01**	**06**
Jan. 11	2 occ. 1	P	1738	1757	41	00
Jan. 11	2 ecl. 1	A	1843	1917	72	01
Jan. 12	**2 ecl. 1**	**A**	**0140**	**0205**	**69**	**05**
Jan. 12	**2 occ. 1**	**P**	**0258**	**0311**	**13**	**06**
Jan. 14	2 occ. 1	P	2225	2234	01	06
Jan. 15	2 occ. 1	A	0525	0557	40	01
Jan. 15	**2 ecl. 1**	**P**	**0624**	**0655**	**62**	**00**
Jan. 15	**2 ecl. 1**	**A**	**1519**	**1538**	**69**	**06**
Jan. 15	2 occ. 1	P	1613	1626	15	06
Jan. 16	**2 ecl. 3**	**A**	**0728**	**0759**	**30**	**10**
Jan. 16	**2 occ. 3**	**A**	**0923**	**0959**	**23**	**09**
Jan. 18	**2 occ. 1**	**P**	**1153**	**1207**	**03**	**05**
Jan. 18	2 occ. 1	P	1708	1746	39	02
Jan. 18	2 ecl. 1	P	1800	1833	54	01
Jan. 19	**2 ecl. 1**	**A**	**0450**	**0507**	**70**	**06**
Jan. 19	**2 occ. 1**	**P**	**0527**	**0539**	**18**	**06**
Jan. 22	**2 occ. 1**	**P**	**0132**	**0202**	**07**	**05**
Jan. 22	**2 occ. 1**	**P**	**0430**	**0530**	**29**	**03**
Jan. 22	**2 ecl. 1**	**P**	**0527**	**0607**	**37**	**02**
Jan. 22	2 ecl. 1	A	1815	1829	71	06
Jan. 22	2 occ. 1	P	1837	1848	20	06
Jan. 23	**2 ecl. 3**	**P**	**1331**	**1443**	**29**	**08**
Jan. 23	2 occ. 3	A	1521	1814	23	07
Jan. 23	2 ecl. 3	P	1950	2050	03	05
Jan. 25	2 ecl. 1	P	1539	1645	01	04
Jan. 26	**2 ecl. 1**	**A**	**0737**	**0750**	**71**	**06**
Jan. 26	**2 occ. 1**	**P**	**0747**	**0757**	**23**	**06**
Jan. 29	2 occ. 1	P	2054	2104	26	06
Jan. 29	2 ecl. 1	A	2056	2108	68	06
Feb. 02	**2 occ. 1**	**P**	**1002**	**1012**	**29**	**06**
Feb. 02	**2 ecl. 1**	**A**	**1014**	**1026**	**67**	**06**
Feb. 05	2 occ. 1	P	2308	2317	33	06
Feb. 05	2 ecl. 1	A	2330	2341	69	06
Feb. 09	**2 occ. 1**	**P**	**1214**	**1223**	**36**	**06**
Feb. 09	**2 ecl. 1**	**A**	**1246**	**1256**	**70**	**06**
Feb. 13	**2 occ. 1**	**P**	**0119**	**0128**	**39**	**06**
Feb. 13	**2 ecl. 1**	**A**	**0200**	**0209**	**70**	**06**
Feb. 16	2 occ. 1	A	1425	1433	40	06
Feb. 16	2 ecl. 1	A	1513	1522	69	06
Feb. 20	**2 occ. 1**	**A**	**0329**	**0337**	**40**	**06**
Feb. 20	**2 ecl. 1**	**A**	**0426**	**0434**	**67**	**06**
Feb. 20	3 occ. 4	P	1517	1612	01	13
Feb. 21	**3 occ. 4**	**P**	**0105**	**0327**	**12**	**09**
Feb. 23	2 occ. 1	P	1634	1642	38	06
Feb. 23	2 ecl. 1	A	1738	1746	68	06
Feb. 27	**2 occ. 1**	**P**	**0539**	**0546**	**35**	**06**
Feb. 27	**2 ecl. 1**	**A**	**0650**	**0658**	**65**	**05**
Mar. 01	4 ecl. 2	P	1612	1645	79	09
Mar. 02	**4 ecl. 2**	**P**	**0500**	**0528**	**08**	**03**
Mar. 02	2 occ. 1	P	1844	1852	31	06
Mar. 02	2 ecl. 1	A	2001	2009	61	05
Mar. 06	**2 occ. 1**	**P**	**0749**	**0756**	**27**	**06**
Mar. 06	**2 ecl. 1**	**A**	**0912**	**0919**	**60**	**05**
Mar. 09	2 occ. 1	P	2055	2101	24	06
Mar. 09	2 ecl. 1	A	2222	2229	59	05
Mar. 10	**2 ecl. 4**	**P**	**0337**	**0349**	**25**	**04**
Mar. 13	**2 occ. 1**	**P**	**1000**	**1006**	**20**	**06**
Mar. 13	**2 ecl. 1**	**A**	**1132**	**1139**	**57**	**05**
Mar. 16	2 occ. 1	P	2306	2311	17	05
Mar. 17	**2 ecl. 1**	**A**	**0042**	**0049**	**55**	**05**
Mar. 17	4 occ. 3	P	1822	1920	00	12
Mar. 17	**4 occ. 3**	**P**	**2150**	**0214**	**11**	**10**
Mar. 18	3 ecl. 2	P	1626	1630	01	05
Mar. 18	4 ecl. 2	T	1938	1947	36	07
Mar. 20	2 occ. 1	P	1211	1216	14	05
Mar. 20	2 ecl. 1	A	1352	1359	52	05
Mar. 20	4 ecl. 3	P	2301	2316	01	14
Mar. 24	**2 occ. 1**	**P**	**0118**	**0122**	**12**	**05**
Mar. 24	**2 ecl. 1**	**P**	**0301**	**0308**	**49**	**04**
Mar. 25	3 ecl. 2	P	1939	1945	13	05
Mar. 27	2 ecl. 4	P	1151	1159	08	02
Mar. 27	2 occ. 1	P	1424	1428	09	05
Mar. 27	2 ecl. 1	P	1610	1617	46	04
Mar. 28	1 ecl. 2	P	2306	2310	20	01
Mar. 29	**1 ecl. 3**	**P**	**0613**	**0622**	**01**	**04**

This table first gives the date of an event in universal time or UT. Next is the form of event, where the satellites are numbered 1 for Io, 2 for Europa, 3 for Ganymede, and 4 for Callisto. The occulting or eclipsing satellite is given first, followed by "occ." for occultation or "ecl." for eclipse, and then by the occulted or eclipsed satellite. Next is the type of event, P for partial, A for annular, or T for total. Then follow the universal times of the event's beginning and end, each given in hhmm. (Subtract 5 hours to convert to EST, 6 hours for CST, 7 hours for MST, and 8 hours for PST.) The next set of two digits is the maximum light loss (DL) in percent. The last item is the apparent distance from Jupiter's center in Jovian equatorial radii (R). Events shown in boldface are visible from all or part of the contiguous United States. Events shown in blue can be observed visually but are not recommended for photoelectric photometry.

Io. Because fresh volcanic material has a different color than older deposits, two-color photometry can help us map where new volcanic eruptions are located. Rapidly alternate between B and V filters to give standard blue-visual color differences.

CCD imaging can also record brightness changes. Videotapes made with a CCD camera may be useful for later analysis even if you don't have suitable image-analysis hardware or software right now.

Let Us Hear from You

If you are interested in doing photoelectric photometry of mutual events, read the article "Predictions of Mutual Phenomena of the Galilean Satellites in 1990-1992" by K. Aksnes and F. Franklin in the April 1990 issue of *Icarus*. This was the source for the table of predictions given here. American observers can

UT Date	Event	Type of Event	UT Begin	UT End	DL	R
Mar. 31	**2 occ. 1**	**P**	**0330**	**0334**	**07**	**05**
Mar. 31	**2 ecl. 1**	**P**	**0520**	**0526**	**42**	**04**
Apr. 01	1 ecl. 2	P	1213	1217	27	01
Apr. 01	3 ecl. 2	P	2252	2300	45	06
Apr. 03	2 occ. 1	P	1637	1641	05	05
Apr. 03	2 ecl. 1	P	1828	1834	38	04
Apr. 04	4 ecl. 1	P	1353	1529	21	05
Apr. 05	**1 ecl. 2**	**P**	**0120**	**0124**	**34**	**01**
Apr. 05	1 ecl. 3	P	1041	1108	09	03
Apr. 05	4 ecl. 1	P	1346	1350	00	04
Apr. 07	**2 occ. 1**	**P**	**0544**	**0548**	**04**	**05**
Apr. 07	**2 ecl. 1**	**P**	**0737**	**0743**	**33**	**04**
Apr. 08	1 ecl. 2	P	1427	1431	38	01
Apr. 09	**3 ecl. 2**	**P**	**0207**	**0215**	**78**	**06**
Apr. 10	2 occ. 1	P	1851	1854	03	05
Apr. 10	2 ecl. 1	P	2046	2051	29	04
Apr. 12	**1 ecl. 2**	**P**	**0333**	**0338**	**50**	**01**
Apr. 12	3 occ. 4	P	1004	1112	11	05
Apr. 13	1 ecl. 4	P	1605	1611	07	07
Apr. 13	2 ecl. 4	P	2111	2118	03	09
Apr. 14	**2 occ. 1**	**P**	**0759**	**0802**	**02**	**05**
Apr. 14	2 ecl. 1	P	0954	0959	25	04
Apr. 15	**3 ecl. 4**	**P**	**0121**	**0145**	**43**	**19**
Apr. 15	1 ecl. 2	P	1640	1645	56	02
Apr. 16	**3 ecl. 2**	**P**	**0522**	**0531**	**97**	**07**
Apr. 16	3 ecl. 1	P	1209	1211	00	03
Apr. 17	2 occ. 1	P	2107	2109	02	05
Apr. 17	2 ecl. 1	P	2302	2307	21	04
Apr. 19	**1 ecl. 2**	**P**	**0547**	**0552**	**64**	**02**
Apr. 20	4 ecl. 3	P	2306	2316	03	11
Apr. 21	2 occ. 1	P	1015	1017	01	05
Apr. 21	2 ecl. 1	P	1210	1216	16	03
Apr. 21	4 ecl. 1	P	1848	1856	52	02
Apr. 22	4 ecl. 2	P	1323	1330	03	05
Apr. 22	1 ecl. 2	P	1854	1900	71	02
Apr. 23	3 ecl. 2	P	0838	0847	91	07
Apr. 23	3 ecl. 1	P	1452	1457	04	03
Apr. 24	2 occ. 1	P	2323	2325	01	04
Apr. 25	**2 ecl. 1**	**P**	**0118**	**0123**	**12**	**03**
Apr. 26	**1 ecl. 2**	**A**	**0802**	**0807**	**80**	**02**
Apr. 27	1 ecl. 3	P	1700	1702	00	07
Apr. 28	2 occ. 1	P	1232	1234	01	04
Apr. 28	2 ecl. 1	P	1427	1431	08	03
Apr. 29	1 ecl. 4	T	2052	2102	52	02
Apr. 29	1 ecl. 2	A	2109	2114	85	02
Apr. 29	2 ecl. 4	A	2202	2236	47	02
Apr. 30	3 ecl. 2	P	1155	1203	65	07
Apr. 30	3 ecl. 4	P	1531	1542	18	09
Apr. 30	3 ecl. 1	P	1738	1744	20	04
May 01	**2 ecl. 4**	**P**	**0410**	**0412**	**00**	**14**
May 02	**2 occ. 1**	**P**	**0140**	**0142**	**01**	**04**
May 02	**2 ecl. 1**	**P**	**0335**	**0338**	**04**	**03**
May 03	1 ecl. 2	A	1016	1022	87	02
May 04	1 ecl. 3	P	1949	1953	01	06
May 05	2 occ. 1	P	1449	1451	02	04
May 05	2 ecl. 1	P	1642	1646	02	03
May 06	1 ecl. 2	A	2324	2329	85	02
May 07	3 ecl. 2	P	1512	1520	39	08
May 07	3 ecl. 1	P	2025	2032	43	04
May 08	**4 ecl. 1**	**P**	**0116**	**0132**	**47**	**06**
May 08	4 ecl. 1	P	1041	1103	81	01
May 09	**4 ecl. 1**	**A**	**0330**	**0342**	**78**	**04**
May 09	**2 occ. 1**	**P**	**0357**	**0400**	**02**	**04**
May 09	**2 ecl. 1**	**P**	**0550**	**0553**	**01**	**03**
May 10	**4 ecl. 3**	**A**	**0431**	**0455**	**66**	**14**
May 10	1 ecl. 2	A	1231	1237	81	02
May 11	1 ecl. 3	P	2236	2242	06	06
May 12	**2 ecl. 3**	**P**	**0427**	**0431**	**00**	**08**
May 12	2 occ. 1	P	1707	1709	03	04
May 12	2 ecl. 1	P	1858	1900	00	03
May 14	**1 ecl. 2**	**P**	**0139**	**0144**	**75**	**02**
May 14	3 ecl. 2	P	1830	1838	12	08
May 14	3 ecl. 1	P	2316	2324	66	05
May 16	3 ecl. 4	A	0047	0102	64	04
May 16	**2 occ. 1**	**P**	**0616**	**0618**	**04**	**04**
May 16	2 ecl. 1	P	0805	0807	00	03
May 17	**1 ecl. 4**	**P**	**0610**	**0619**	**36**	**07**
May 17	1 ecl. 2	P	1447	1452	68	03
May 19	1 ecl. 3	P	0122	0128	17	05
May 19	2 ecl. 3	P	0742	0748	05	08
May 19	2 occ. 1	P	1925	1928	06	04
May 19	2 ecl. 1	P	2113	2114	00	02
May 21	**1 ecl. 2**	**P**	**0355**	**0400**	**61**	**03**
May 21	3 ecl. 2	P	2150	2155	01	08
May 22	**3 ecl. 1**	**P**	**0211**	**0220**	**88**	**05**
May 23	2 occ. 1	P	0835	0838	08	04
May 24	1 ecl. 2	P	1703	1708	56	03
May 25	4 ecl. 3	T	1823	1836	51	01
May 26	**1 ecl. 3**	**P**	**0406**	**0412**	**29**	**04**
May 26	2 ecl. 3	P	1056	1104	20	08
May 26	2 occ. 1	P	2144	2148	10	04
May 28	**1 ecl. 2**	**P**	**0611**	**0616**	**49**	**03**
May 28	3 occ. 2	P	2143	2146	01	07
May 29	3 ecl. 2	P	0112	0114	00	08
May 29	**3 ecl. 1**	**P**	**0512**	**0523**	**98**	**06**
May 30	2 occ. 1	P	1054	1058	13	03
May 31	1 ecl. 2	P	1919	1925	43	03

write to Dr. Fred Franklin, Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138 for further information, including observing techniques. Another expert willing to help potential observers is Dr. Jean E. Arlot, Bureau des Longitudes; 77, avenue Denfert-Rochereau; 75014 - Paris, France.

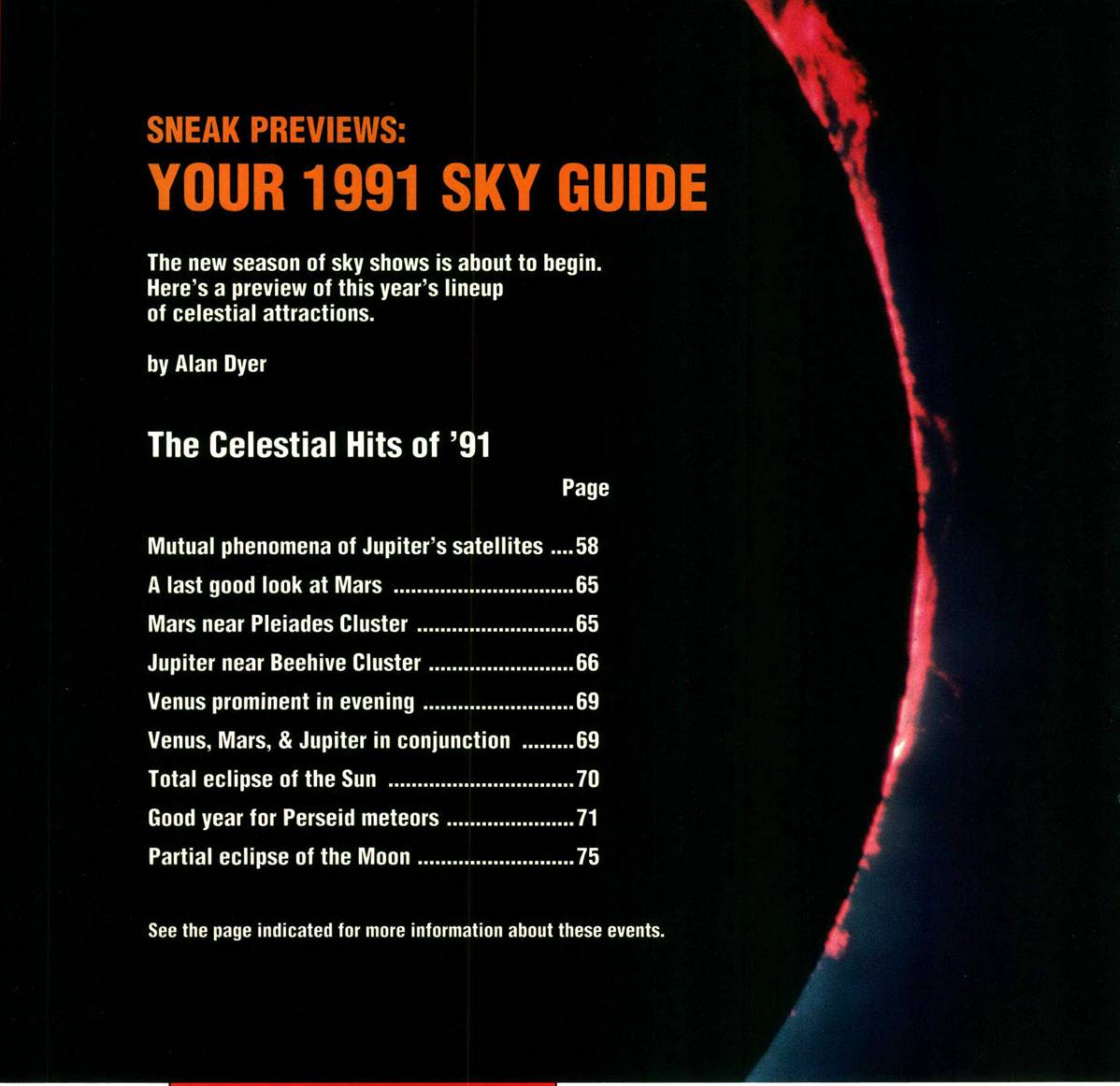
But remember that communication works both ways. Your observations will not help astronomers to better understand the Jovian system if you keep them to yourself. The author (address: P.O. Box 16131, San Francisco, CA 94116) will be happy to receive drawings, photographs, and *copies* of videotapes (VHS or S-VHS format) to be selected for publication by the Association of Lunar and Planetary Observers.

Two-color (B-V) photometry of the occultations of Io by Europa should also be sent to the author, who will make it available to the "International Jupiter Watch — Satellite Division," a group that is organizing studies of the volcanic activity on Io.

Copies of any electronic data recording — videotapes, digital images, photoelectric readings — should be sent to both Dr. Franklin and Dr. Arlot, who are prepared to analyze your observations in order to refine our knowledge of these worlds and of their orbits about Jupiter.

Remember, though, that the Jovian mutual events belong to all of us. Watch them even if all you get from the process is the personal satisfaction of following the antics of the four worlds first spotted by Galileo almost four centuries ago. □

John E. Westfall is executive director of the Association of Lunar and Planetary Observers.



SNEAK PREVIEWS:

YOUR 1991 SKY GUIDE

The new season of sky shows is about to begin. Here's a preview of this year's lineup of celestial attractions.

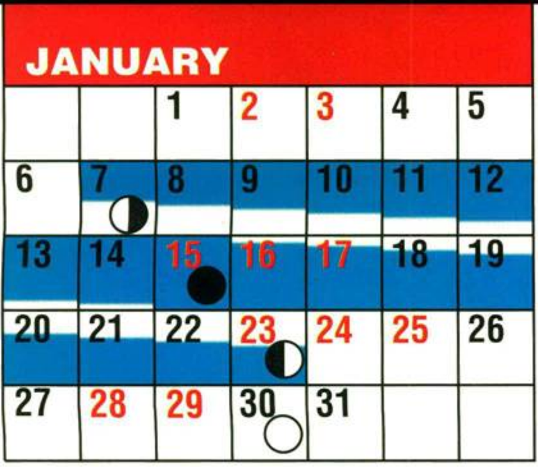
by Alan Dyer

The Celestial Hits of '91

Page

Mutual phenomena of Jupiter's satellites 58
A last good look at Mars 65
Mars near Pleiades Cluster 65
Jupiter near Beehive Cluster 66
Venus prominent in evening 69
Venus, Mars, & Jupiter in conjunction 69
Total eclipse of the Sun 70
Good year for Perseid meteors 71
Partial eclipse of the Moon 75

See the page indicated for more information about these events.



JANUARY

		1	2	3	4	5
6	7 ◑	8	9	10	11	12
13	14	15 ●	16	17	18	19
20	21	22	23 ◐	24	25	26
27	28	29	30 ○	31		

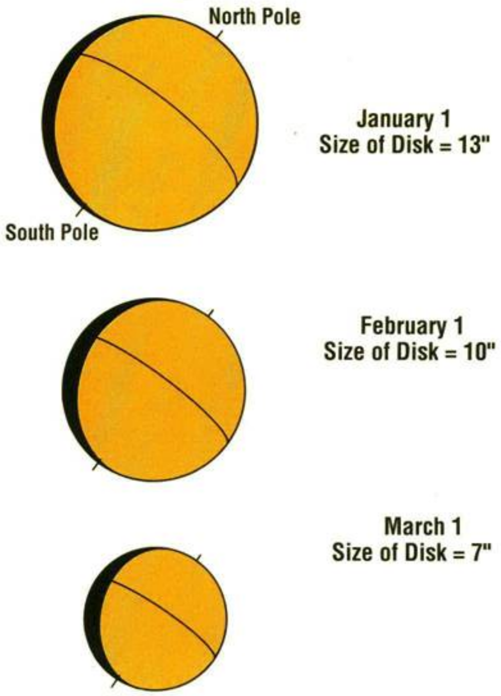
Day	Hour (UT)	
2	21	Jupiter appears without satellites for 1 hour (Europe)
	23	Jupiter 2° north of Full Moon
3	03	Earth closest to the Sun
4	03	Quadrantid meteors peak (poor circumstances)
15	23	4 Galilean moons in order on west side of Jupiter
16	00	Annular solar eclipse (Australia, Pacific)
17	01	Jupiter appears with one moon (evening, N. America)
	18	Venus 3° south of crescent Moon
24	02	Jupiter appears with one moon (evening, N. America)
25	02	4 Galilean moons in order on east side of Jupiter
	12	Moon occults Pleiades Cluster (Australia, Pacific)
	15	Mars 2° south of gibbous Moon
29	00	Jupiter at opposition
30	02	4 Galilean moons in order on west side of Jupiter
	05	Jupiter 1.8° north of Full Moon & 1.5° south of M44
	06	Full Moon — penumbral lunar eclipse (N. America)

A FAREWELL TO MARS

In early 1991, the curtain comes down on a great season of Mars watching. After performing one of its rare close approaches to Earth in late November 1990, Mars recedes from us as the new year opens. Each night, Mars is a little farther away and its disk a little smaller through a telescope.

The best time to view the Red Planet as it slips away from Earth is during January and February. During those months Mars will appear as a bright orange "star" high in the east just after sunset. It will spend most of January just below the distinctive cluster of stars called the Pleiades, or Seven Sisters. By February Mars will have slid farther east to the area of the sky just above the sprawling star cluster called the Hyades, which marks the face of Taurus the Bull. Through the rest of the late winter and spring, Mars continues its trek eastward against the starry backdrop, moving into Gemini in April, where it passes 1° north of the star cluster M35 on April 5 and a mere 18 arcminutes south of the 3rd-magnitude star Epsilon Geminorum on April 20. By June Mars catches up to Jupiter in Cancer. By then that part of the spring sky will be low in the west at sunset. Venus joins the planetary gathering in June as well.

Early in 1991 those with telescopes should make the effort to brave the mid-winter nights to zoom in on Mars. Until the end of January, the disk of the Red Planet remains larger than 10 arcseconds across, large enough to show some dark surface markings, provided our own atmosphere cooperates with steady "seeing" conditions.



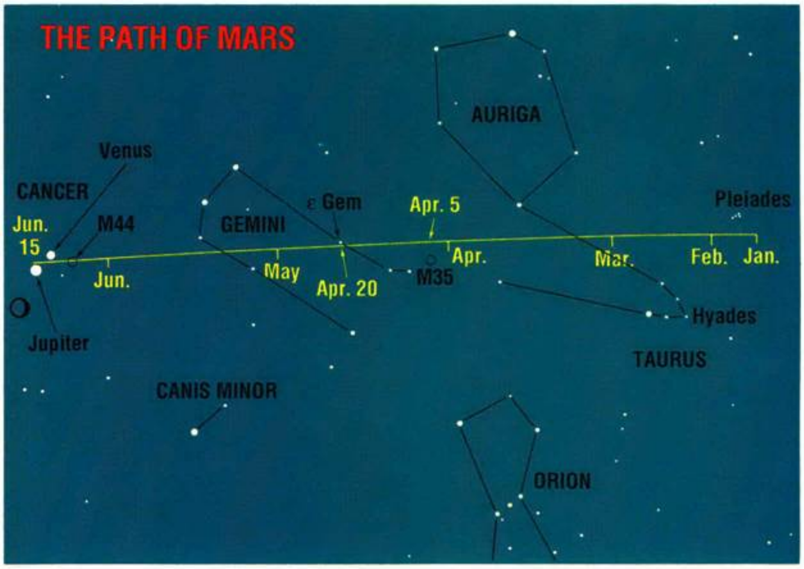
WHAT'S UT?

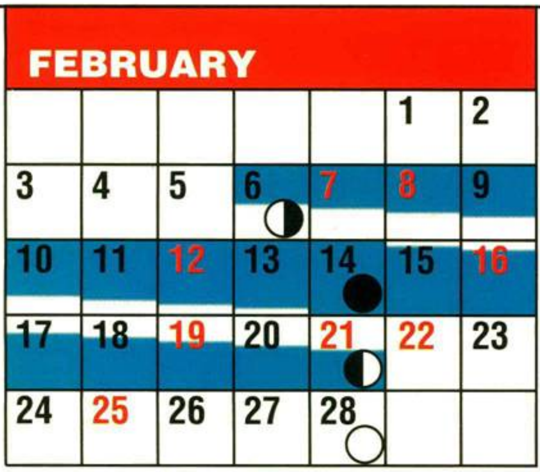
When giving times for a celestial event that will be visible over a large geographic area (perhaps over the entire globe), astronomers often use Coordinated Universal Time, abbreviated UTC or just UT. This is the standard time at Greenwich, England, given in the 24-hour style (4 p.m. = 16:00). To find out the time in your time zone subtract the appropriate number of hours:

Time Zone	Standard Time	Daylight Savings
Atlantic	–4	–3
Eastern	–5	–4
Central	–6	–5
Mountain	–7	–6
Pacific	–8	–7
Alaska	–9	–8
Hawaii	–10	na

Watch your dates when converting! For example, a time given as 4 hours UT on June 15 will convert to 11 p.m. Central Daylight Time on the 14th.

Venus, Jupiter, and Moon shown for June 15.





FEBRUARY						
					1	2
3	4	5	6 ◑	7	8	9
10	11	12	13	14 ●	15	16
17	18	19	20	21 ◐	22	23
24	25	26	27	28 ○		

Day	Hour (UT)	
7	--	Jupiter 1° south of Beehive Cluster M44
8	07	4 Galilean moons in order on east side of Jupiter
	11	Antares occulted by Moon (southeast U.S., Caribbean)
12	18	Saturn occulted by Moon (Hawaii, morning)
17	02	Venus 6° south of crescent Moon
20	01	4 Galilean moons in 2 pairs on west side of Jupiter
21	18	Pleiades occulted by Moon (Asia)
22	08	Mars 8° north of Aldebaran, 1.6° south of gibbous Moon
	23	4 Galilean moons in 2 pairs on east side of Jupiter
26	09	Jupiter 1.6° north of Full Moon

Dark sky observing windows are indicated by the blue shadings. At First Quarter Moon the sky is dark during the last half of the night after moonset. At Last Quarter the sky is dark during the first half of the night before moonrise.

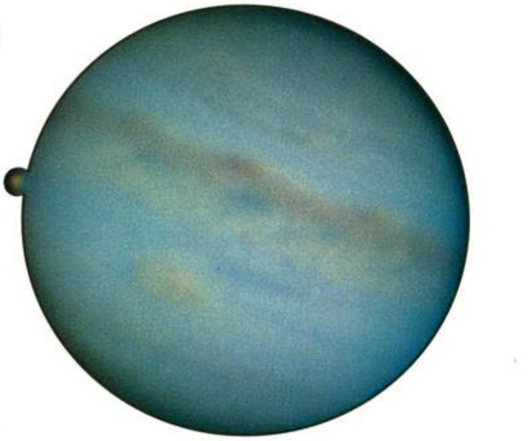
JUPITER AND ITS MOONS: FLIRTY DANCING

As the Mars show comes to an end, the Jupiter show reaches a peak of activity. In 1991, Jupiter, like Mars, spends a good deal of its time close to a bright star cluster. In Jupiter's case it's M44, the Beehive Cluster in Cancer. Jupiter is directly opposite the Sun on January 29. At that time it will be as close to Earth as it gets all year and will be rising at sunset. Until mid-July Jupiter is a prominent evening object. Then it takes its bow in mid-summer, disappearing behind the Sun for a few weeks and then reappearing once again in the morning sky in early September. But the convenient evening time slots make January to May the prime viewing season for Jupiter this year.

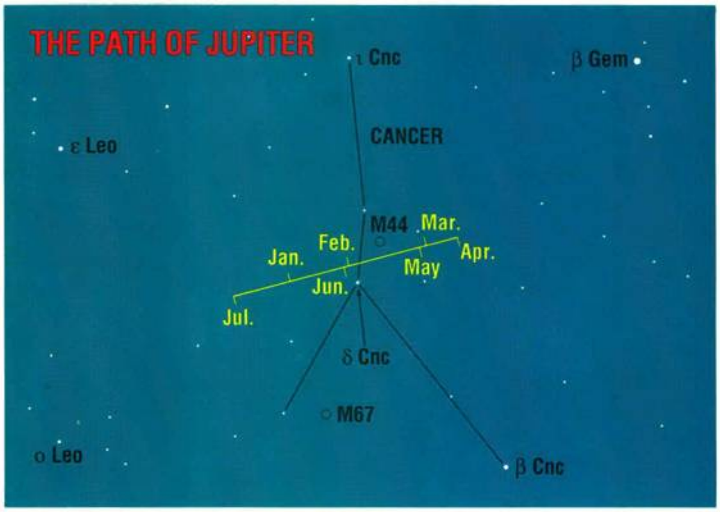
At center stage is the planet's ever-changing cloud patterns. They are one of the most rewarding targets for any size telescope. In late 1990, planet watchers witnessed an eruption of activity as the dark South Equatorial cloud belt, missing since July 1989, began to reappear. Meanwhile, the Great Red Spot, looking pastel pink and prominent throughout 1990, appeared to be fading into a ghost of its former self, back to the pale gray spot it looked like through most of the late 1980s.

Surrounding the giant planet is a non-stop sideshow that in early 1991 is likely to upstage even the ever-changing Jovian cloud patterns. Jupiter's four large Galilean moons will be putting on a dance performance that should draw fans night after night. As the moons waltz back and forth they will pass in front of one another and cast their shadows onto one another. These mutual occultations and eclipses among the four moons will occur almost nightly through this year's Jupiter observing season. On page 58 you'll find more details on the Jovian moon show along with a complete program of events.

While you're watching Jupiter, be sure to look for moons passing behind and in front of the planet itself. These events will be ongoing throughout the year. In fact on many nights, you'll see only two or three moons around Jupiter; the others may be transiting across the face of the planet, perhaps casting their inky black shadows onto the cloudtops of Jupiter, or they may be behind Jupiter or hidden in the shadow of the planet. In all, the number of possible events makes for a fascinating Jovian scene that is never the same from one night to the next.



ONE BELT AND A VERY RED SPOT dominated Jupiter's clouds in 1990. In 1991, the missing South Equatorial Belt may return to its former prominence. Also note the Galilean moon hovering near the limb of the planet. Photo by Donald C. Parker.



MARCH						
					1	2
3	4	5	6	7	8 ◑	9
10	11	12	13	14	15	16 ●
17	18	19	20	21	22	23 ◐
24 31	25	26	27	28	29	30 ○

Day	**Hour** (UT)	
6	00	4 Galilean moons on west side of Jupiter
	08	Asteroid Pallas at opposition
7	19	Antares 0.8° south of Last Quarter Moon
12	08	Saturn occulted by crescent Moon (Europe)
16	01	4 Galilean moons in order on east side of Jupiter
	--	Look for very young Moon (N. America)
17	15	Mercury 5° south of thin crescent Moon
19	00	Venus 5° south of crescent Moon
21	03	Vernal equinox — spring begins
22	17	Mars occulted by Moon (NE Canada, British Isles)
25	13	Jupiter 1.6° north of gibbous Moon
27	15	Mercury at greatest eastern elongation (evening)
30	04	*4 Galilean moons in order on east side of Jupiter*

TWIN PEEKS AT MERCURY

Have you ever heard about a new movie that you really wanted to see — only to find out it played for just a couple of weeks and had already been pulled from the theaters? Well, Mercury is sort of like that. It plays on the celestial stage only at select times.

In 1991 Mercury appears for brief intervals on seven occasions, four morning appearances and three evening appearances. Each limited engagement lasts only from three to six weeks. However, of the seven appearances, only two (one evening and one morning) are best for Northern Hemisphere observers.

For a peek at Mercury in the evening sky look during the last two weeks of March. About 30 minutes after sunset it will appear as a 1st-magnitude star 5° to 10° above the western horizon amid the twilight glow. Find a location with a clear view to the west and scan the area with binoculars. Don't be fooled by Venus — it will be a brilliant object about 20° up. Mercury will be much dimmer and halfway between Venus and the horizon.

Through a telescope, Mercury will show a disk only 6 to 8 arcseconds across (roughly half the diameter of Saturn's disk). At best you can follow the rapidly changing size and phase of Mercury each night, but don't expect to see any detail on the planet. The disk is too small and usually too blurred by the shimmering atmosphere near the horizon.

If you miss the spring evening appearance, you can catch Mercury in the morning sky in the fall. It will be low in the east just before sunrise. Oddly enough, Venus will also be in the morning sky by then as well, along with Jupiter. A good morning to look will be on either September 6 or 7, when the waning crescent Moon will join the trio of Mercury, Venus, and Jupiter low in the sky almost due east.

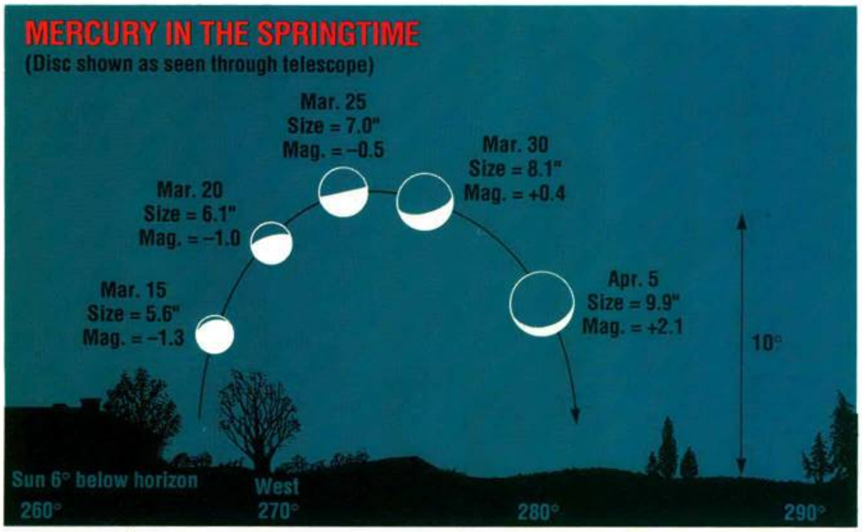
MERCURY'S PEAK TIMES

Evening Elongations

Date	Visible During ...	Max. Angle from Sun
Mar. 27	Mar. 12 – Apr. 6	19° (best)
July 25	June 25 – Aug. 15	27°
Nov. 19	Oct. 18 – Dec. 3	22°

Morning Elongations

Date	Visible During ...	Max. Angle from Sun
Jan. 14	Jan. 1 – Feb. 18	24°
May 12	Apr. 23 – June 10	26°
Sept. 7	Aug. 30 – Sept. 23	18° (best)
Dec. 27	Dec. 14 – Dec. 31	22°



MERCURY IN THE SPRINGTIME
(Disc shown as seen through telescope)

APRIL

	1	2	3	4	5	6
7 ◑	8	9	10	11	12	13
14 ●	15	16	17	18	19	20
21 ◐	22	23	24	25	26	27
28 ○	29	30				

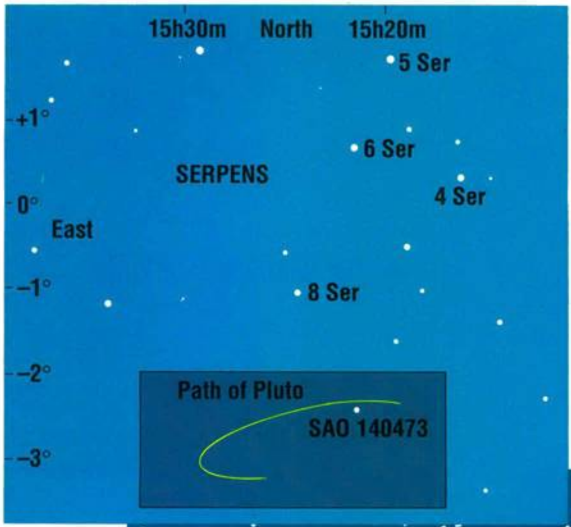
Day	Hour (UT)	
4	03	Antares occulted by Moon (Europe, British Isles)
6	04	Mars 1° north of star cluster M35
7	--	Spring ahead 1 hour to Daylight Saving Time
	00	Uranus occulted by Moon (Australia)
8	21	Saturn 1.4° south of Last Quarter Moon
12	--	Venus 3° south of Pleiades Cluster
13	01	4 Galilean moons on east side of Jupiter
17	16	Venus 2° south of crescent Moon (evening)
	16	Asteroid Ceres at opposition
20	--	ASTRONOMY DAY
	00	Mars occulted by Moon (South Pacific)
	01	4 Galilean moons on east side of Jupiter
21	04	Mars 0.3° south of magnitude 3.0 star Epsilon Gem
	19	Jupiter 1.9° north of First Quarter Moon
22	14	Lyrid meteors peak (fair circumstances)
26	03	4 Galilean moons in order on west side of Jupiter

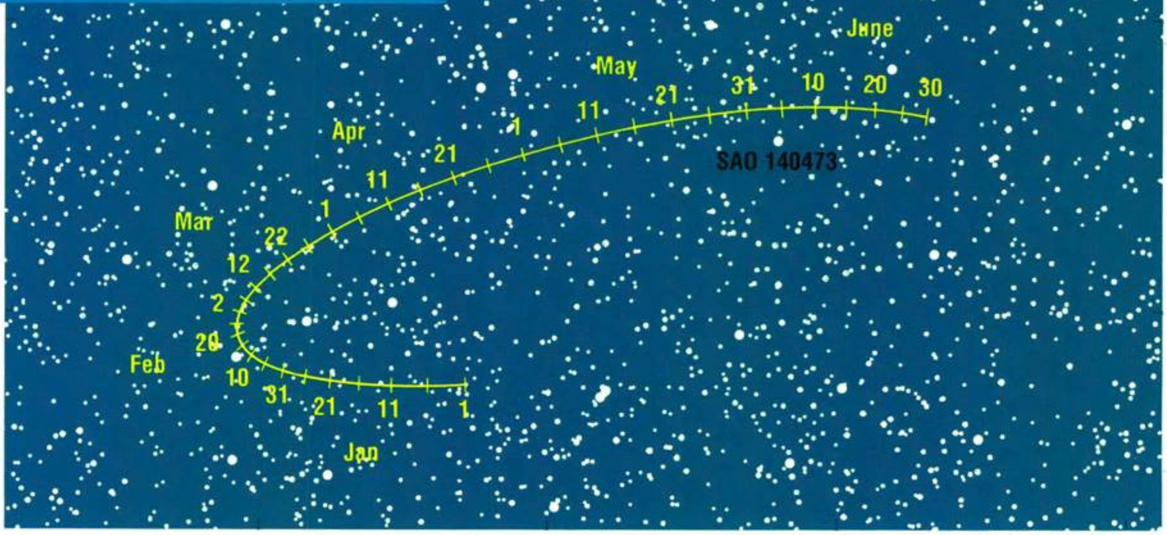
THE HUNT FOR DISTANT PLUTO

If you want to make 1991 the year you collect views of all eight planets, then you'll need to find faint Pluto. April and May are the best months for Pluto hunting. On May 10 Pluto will be closest to Earth for 1991 (if you call 2.6 billion miles close!) and at its brightest (if you call magnitude 14 bright!). At its best, Pluto will appear only as a very faint star, so dim you'll need at least an 8-inch telescope to see it. A 10- or 12-inch scope would be far better.

In 1991 Pluto will be moving slowly across a small section of the sky on the Serpens-Libra border. The top star map shows an area about 6° square and includes the 5th magnitude stars numbered 4, 5, and 6 Serpentis. They can be found on most detailed star charts (like *Sky Atlas 2000.0* or *Uranometria 2000.0*). Locate the area of the sky using one of those star charts, then use our finder chart as a guide to hop from star to star into the target area.

The faintest stars on the close-up chart below are magnitude 15, just slightly fainter than Pluto. Since Pluto will be well-camouflaged among the surrounding stars, the way to nab Pluto is to wait for it to move. Make a sketch of the field on one night and return to the field one or two nights later. If you find a star that has shifted during that time, you've found Pluto. The finder chart below is based on the Hubble Guide Star Catalogue and is courtesy Doug Mink, Harvard-Smithsonian Center for Astrophysics.

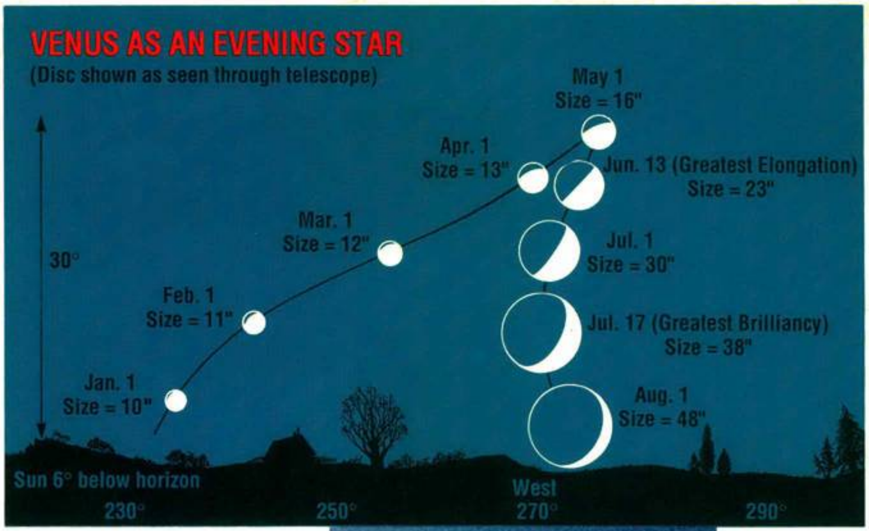




MAY						
			1	2	3	4
5	6	7 ◑	8	9	10	11
12	13	14 ●	15	16	17	18
19	20 ◐	21	22	23	24	25
26	27	28 ○	29	30	31	

Day	**Hour** (UT)	
5	14	Eta Aquarid meteors peak (fair circumstances)
6	07	Saturn 1.8° south of Last Quarter Moon
10	03	Pluto at opposition
14	--	Look for very young Moon (N. America)
17	07	Venus 1.6° north of crescent Moon
18	10	Mars 2° north of Moon
19	07	Jupiter 2° north of First Quarter Moon
	--	Jupiter 1° south of Beehive Cluster M44
31	13	Uranus occulted by Moon (Australia, New Zealand)

VENUS: JEWEL FOR AWHILE



Through the first half of 1991, Venus will be the brilliant star of the evening. From January to June, you'll find Venus about 20° to 30° above the western horizon as the sky begins to darken. With a magnitude of roughly – 4, Venus will outshine every other star and planet and will be the first "star" to emerge from the twilight glow.

Through the winter and early spring Venus will be on the far side of its orbit, coming out from behind the Sun. Through a small telescope, you'll be able to watch it change from full to quarter phase and its disk double in size from 10 arcseconds to over 20 arcseconds in diameter.

As the separation between Venus and the Sun widens, Venus travels eastward through the constellations. From April 10 to 14, Venus will be close to the Pleiades cluster in Taurus. On April 17 the crescent Moon will be only 2° from Venus, making for a beautiful evening scene. In fact, April 17 is a good day to look for Venus in broad daylight. If you can find the Moon before sunset it should then be easy to pick out Venus just to the right of the Moon. Binoculars will help, but Venus is so bright it's possible to see it with the unaided eye in the clear blue sky. Try it! May 17 and June 15 are two other good days for using the crescent Moon to guide you to daytime sightings of Venus.

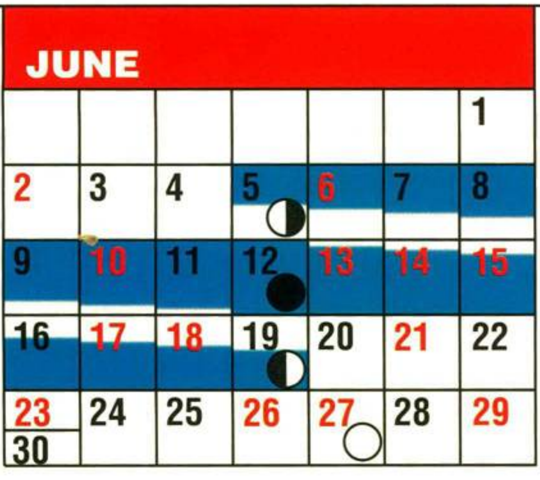
The evening sky will get rather crowded in the spring. From May 16 to 18 Venus, Mars, and Jupiter will form a neat line across the western sky with the crescent Moon passing each planet in turn over the three evenings. By June 15, all three planets will be clustered together in a tight trio, with the crescent Moon also nearby. At this time Venus is at "greatest eastern elongation," meaning that it is now as far east of the Sun as it will get. Venus will then "round the corner" of its orbit and start to head between Earth and the Sun. From mid-June to early August, the altitude of Venus above the western horizon will drop from night to night as the angle between Venus and the Sun closes. This will be the most interesting time to watch Venus through a telescope: the phase of Venus will go quickly from quarter to a delicate thin crescent, and the size of the disk will balloon from 23 arcseconds to over 50 arcseconds.

By early August, Venus will be gone from the evening sky and will set at the same time as the Sun. Venus passes between us and the Sun (an event called "inferior conjunction") on August 22. It then begins a repeat performance on the other side of the Sun in the morning sky. It will climb high into the eastern dawn sky and become an impressive morning star in the autumn skies. On October 16 and 17, it will form a striking pair with Jupiter.

A CRESCENT VENUS was captured in the daytime sky by Jim Baumgardt as that planet passed 6° north of the Sun at inferior conjunction on January 18, 1990.

A DATE WITH VENUS

June 13	Greatest Eastern Elongation (evening)
July 17	Greatest Brilliancy (mag. –4.4)
Aug. 22	Inferior Conjunction
Sept. 28	Greatest Brilliancy (mag. –4.4)
Nov. 2	Greatest Western Elongation (morning)



JUNE

						1
2	3	4	5 ◑	6	7	8
9	10	11	12 ●	13	14	15
16	17	18	19 ◑	20	21	22
23 30	24	25	26	27 ○	28	29

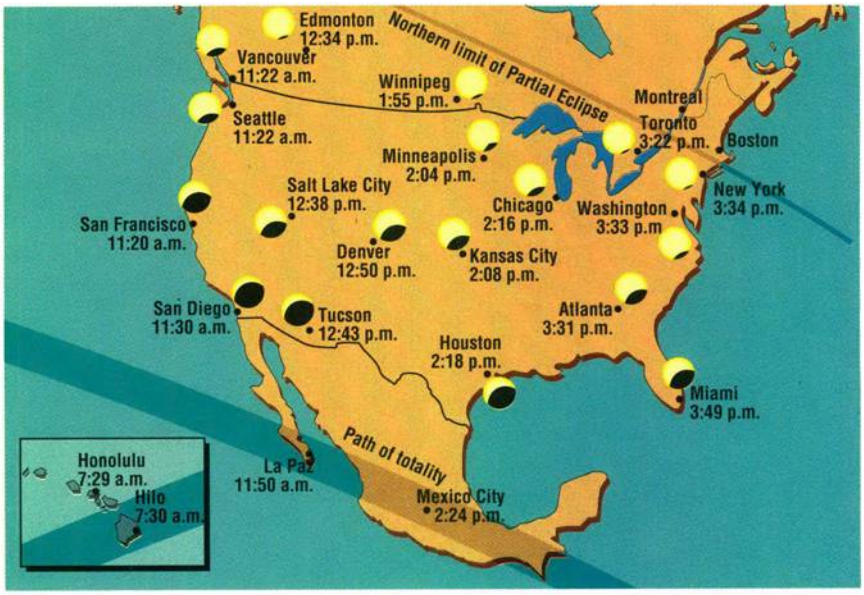
Day	**Hour** (UT)	
2	14	Saturn 2° south of gibbous Moon
7	04	Mars 0.25° south of Beehive Cluster M44
10	--	Uranus 1.8' south of magnitude 5.9 star SAO 187468
13	22	Venus at greatest eastern elongation (evening)
14	05	Mars 0.6° north of Jupiter (evening twilight)
15	20	Venus, Mars, & Jupiter near crescent Moon
17	23	Venus 1.2° north of Jupiter (evening twilight)
18	--	Venus, Mars, and Jupiter closest together
21	21	Summer solstice — summer begins
23	12	Venus 0.3° north of Mars (evening twilight)
27	03	Full Moon — partial penumbral eclipse (eastern N. America)
	17	Uranus occulted by Moon (Australia)
29	18	Saturn 2° south of gibbous Moon

A BRIEF DAY'S JOURNEY INTO NIGHT

The summer blockbuster for 1991 is July's total eclipse of the Sun. For many skywatchers, this is the event of the year. But to see the spectacle you'll have to travel to either the island of Hawaii or the southern tip of Mexico's Baja Peninsula, or to sites along the path of totality in mainland Mexico. (For more information about where to view this eclipse and how to get there see "A Journey Into Darkness," ASTRONOMY, July 1990.) This is not an eclipse to be missed. The chances of clear skies are the finest we'll ever see, and in Mexico the totality lasts almost seven minutes, nearly as long as any eclipse can get.

Those in North America who stay behind on eclipse day must be content with viewing a partial eclipse. The closer you are to the path of totality in Mexico, the more Sun you'll see covered.

There is another solar eclipse in 1991, but it is one North Americans won't see. On the morning of January 16 (local time), an annular eclipse will sweep across the Indian Ocean south of Australia, across New Zealand, and out into the South Pacific. Since the Moon's disk will be smaller than the Sun's, those in the path will see the Sun transformed into a brilliant ring. North Americans will get a chance to see this type of eclipse on home soil in May 1994.


Edmonton
12:34 p.m.
Northern limit of Partial Eclipse
Vancouver
11:22 a.m.
Winnipeg
1:55 p.m.
Montreal
Seattle
11:22 a.m.
Toronto
3:22 p.m.
Boston
Minneapolis
2:04 p.m.
Salt Lake City
12:38 p.m.
New York
3:34 p.m.
Chicago
2:16 p.m.
Washington
3:33 p.m.
San Francisco
11:20 a.m.
Denver
12:50 p.m.
Kansas City
2:08 p.m.
San Diego
11:30 a.m.
Tucson
12:43 p.m.
Atlanta
3:31 p.m.
Houston
2:18 p.m.
Miami
3:49 p.m.
Honolulu
7:29 a.m.
Hilo
7:30 a.m.
La Paz
11:50 a.m.
Path of totality
Mexico City
2:24 p.m.

AN ECLIPSED SUN will be the astronomical highlight of July. Most of North America will see a partial eclipse (such as the October 3, 1986, eclipse shown at right). Viewers along the path of totality will see a rare total eclipse. Photo by Dewey Vanderhoff.

JULY

	1	2	3	4	5 ◑	6
7	8	9	10	11 ●	12	13
14	15	16	17	18 ◐	19	20
21	22	23	24	25	26 ○	27
28	29	30	31			

Day	**Hour** (UT)	
4	07	Uranus at opposition
6	15	Earth farthest from the Sun
8	00	Neptune at opposition
11	19	Total solar eclipse (Hawaii, Baja, and Mexico)
14	16	Mars 0.7° north of Regulus (evening)
15	08	Mercury 4.8' south of Jupiter (evening)
16	23	Asteroid Juno at opposition
17	05	Venus at greatest brilliancy (evening)
22	06	Venus 4° south of Mars (evening twilight)
26	18	Full Moon — partial penumbral eclipse (Australia)
27	00	Saturn at opposition
	--	Neptune 3.6' south of magnitude 3.9 star o Sgr.
29	04	Delta Aquarid meteors peak (poor circumstances)

GREAT BALLS OF FIRE (AND ICE!)

If you want to know if this is a good year for the Perseids the answer is a very definite "Yes!"

Each year Earth crosses the path of several streams of meteoric dust orbiting the Sun. These stream-crossings occur on nearly the same dates every year, yielding a friendly dependability to the celestial schedule. However, how good each shower appears depends in large part on the phase of the Moon at the time of the shower and whether the peak of the shower occurs during nighttime hours from your location. This year, for North American observers both circumstances combine favorably for the Perseid shower, usually considered one of the most active showers of the year. On the night of August 12/13 you should be able to see 60 to 100 meteors per hour. It will make for a memorable midsummer night of astronomy.

The dusty particles that burn up in our atmosphere during a meteor shower come from comets. Each year a handful of periodic comets return to the sky and watchful observers discover a dozen or more new comets. Most remain extremely faint (magnitude 10 or fainter) and visible only in telescopes. During 1991, four comets are expected to become brighter than 10th magnitude, but only slightly.

Comet Takamizawa will be well placed in the evening sky in June and July as it slowly treks through Virgo and Libra. But Takamizawa won't be brighter than magnitude 9.8. Comet Machholz, discovered in 1986, will brighten to magnitude 4.3 during the third week of July, but it will be too close to the Sun to observe. By the time it emerges from behind the Sun it will have faded to a 9th magnitude object in Leo. Comet Hartley 2, also first seen in 1986, will shine at magnitude 9.7 in late August and early September and will be high in the east in the dawn hours as it moves through Auriga and Gemini.

The fourth comet is a friend from August 1990 — Comet Levy. After disappearing behind the Sun in late 1990, it will return to the evening sky in February as a telescopic fuzzball moving north through Hydra into Cancer. From April to July, it will remain 5° to 8° southwest of Jupiter in Cancer, rapidly receding from Earth and fading below magnitude 10.

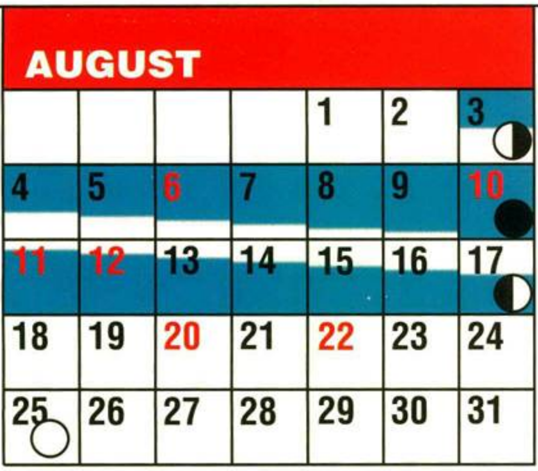
In all, 1991 looks like a poor year for comets. However, the best comet of '91 may be still awaiting discovery by comet hunters like David Levy and Don Machholz.

A PAIR OF METEORS streak across the sky during the Eta Aquarid meteor shower. Photo by M. Clark.

METEOR SHOWERS IN 1991

Shower	**Date**	**Hour** (UT)	**Rate** (#/hr)	**Viewing Circumstances**
Quadrantids	Jan. 4	03	60	poor
Lyrids	Apr. 22	14	10	fair
Eta Aquarids	May 5	14	35	fair
δ Aquarids	July 29	04	20	poor
Perseids	Aug. 13	04	75	excellent !!
Orionids	Oct. 22	07	25	poor
Taurids	Nov. 4	--	10	good
Leonids	Nov .18	03	10	poor
Geminids	Dec. 14	10	75	good

Viewing circumstances depend upon the presence of the Moon and whether the peak of the shower occurs at night for North America.



AUGUST

				1	2	3 ◐
4	5	6	7	8	9	10 ●
11	12	13	14	15	16	17 ◑
18	19	20	21	22	23	24
25 ○	26	27	28	29	30	31

Day	**Hour** (UT)	
7	06	Mercury 2° north of Venus
11	07	Venus 3° south of thin crescent Moon (evening)
	08	Mercury occulted by Moon (Central Europe, Asia)
13	04	Perseid meteors peak (excellent circumstances)
21	02	Uranus 0.4° north of gibbous Moon
	10	Neptune 1.2° north of gibbous Moon
22	20	Venus in conjunction with Sun
	23	Saturn 1.8° south of gibbous Moon

THREE'S COMPANY

THE OPPOSITIONS OF THE GIANTS

Date	Planet	Constellation	Magnitude	Disk Size
Jan. 29	Jupiter	Cancer	–2.6	45.7"
July 4	Uranus	Sagittarius	5.9	3.8"
July 8	Neptune	Sagittarius	7.7	2.3"
July 27	Saturn	Capricornus	0.1	16.9"

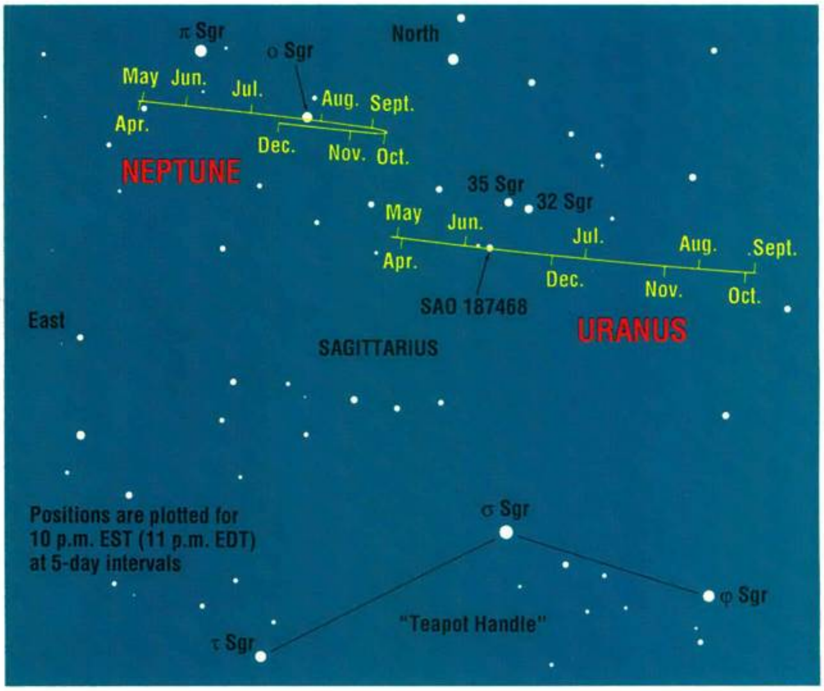
On these dates these planets are opposite the Sun.
They rise at sunset and are due south in the middle of the night.

One of the big hits of the summer and early fall will certainly be Saturn. Its remarkable ring system makes it an unforgettable sight in even the most modest of telescopes. Back in 1989, Saturn, Uranus, and Neptune were together in the same area of the sky just above the Teapot asterism of Sagittarius. Since then, the faster moving Saturn has pulled away from its more distant planetary cousins. Saturn now sits alone and unattended in the star-poor region of Capricornus. With no other bright stars or planets nearby, the 0.5-magnitude planet will be easy to locate. Beginning about June, Saturn will be low in the south (at least for Northern Hemisphere observers) during early evening hours.

During 1991 Saturn's rings continue to close up; with each passing year we are seeing the rings gradually tilt more toward an edge-on aspect. In February the north face of Saturn's rings will be tilted 21° to our line of sight. By year's end they will have closed to 19.5°. By 1995 they will be edge-on and will be reduced to a sliver of light on either side of Saturn.

Meanwhile, Uranus is gradually catching up to Neptune. The two planets spend 1991 within 3° of each other in northern Sagittarius, but by 1993 these two outer gas giants will be within 1°. The proximity of Uranus and Neptune over the next few years is a rare occurrence — the last time they were within 3° of each other was in the 1820s; the next will be in 2163.

This year you'll also be able to see Uranus and Neptune each glide past a bright star. On the night of June 10, Uranus will be within 1.8 arcminutes (108 arcseconds) of a magnitude 5.9 star called SAO 187468. Since Uranus itself is also magnitude 5.9, the two will look like a double star at low power. But high power will reveal Uranus' 4 arcsecond-diameter disk. On July 27, Neptune, shining at magnitude 7.7, will pass within 3.6 arcminutes of 3rd-magnitude Omicron Sagattarii.



Positions are plotted for 10 p.m. EST (11 p.m. EDT) at 5-day intervals

SEPTEMBER

1 ◑	2	3	4	5	6	7
8 ●	9	10	11	12	13	14
15 ◐	16	17	18	19	20	21
22	23 ○	24	25	26	27	28
29	30					

Day	Hour (UT)	
6	17	Venus 5° south of crescent Moon (morning)
7	05	Mercury 3° north of thin crescent Moon
	11	Jupiter 5° north of thin crescent Moon
	18	Mercury at best western elongation (morning)
10	08	Jupiter 0.4° north of Regulus (morning)
	10	Mercury 4.2' south of Jupiter, 18' north of Regulus
17	09	Uranus occulted by Moon (Australia, New Zealand)
19	04	Saturn 1.8° south of gibbous Moon
23	13	Autumnal equinox — fall begins
	23	Full Moon — the Harvest Moon
28	23	Venus at greatest brilliancy (morning)

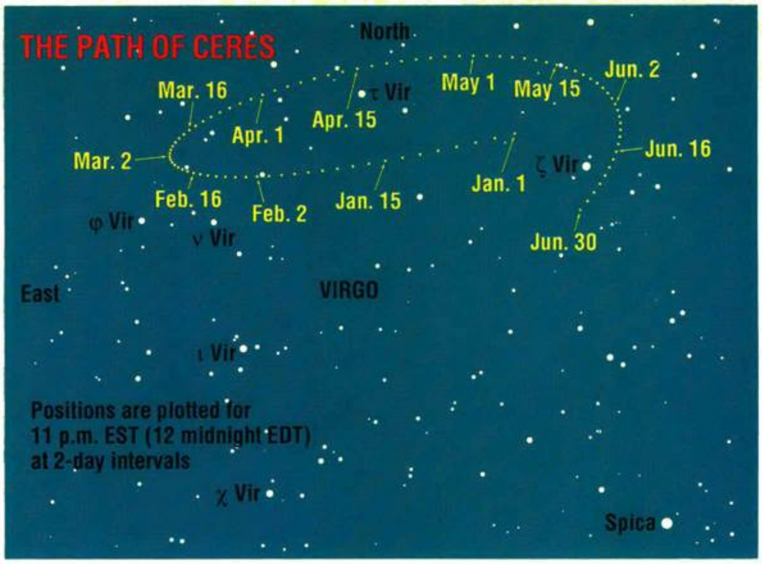
FOUR EASY PIECES

Asteroids are definitely the bit players on the celestial stage, but on some nights they can steal the show. Each year several occultations of stars by asteroids provide opportunities for organized teams of amateur and professional astronomers to measure the sizes and shapes of asteroids. (See "Stand in the Shadow of an Asteroid" on page 54.) In January, North American observers get a chance to see stellar occultations by the asteroids 4 Vesta and 216 Kleopatra.

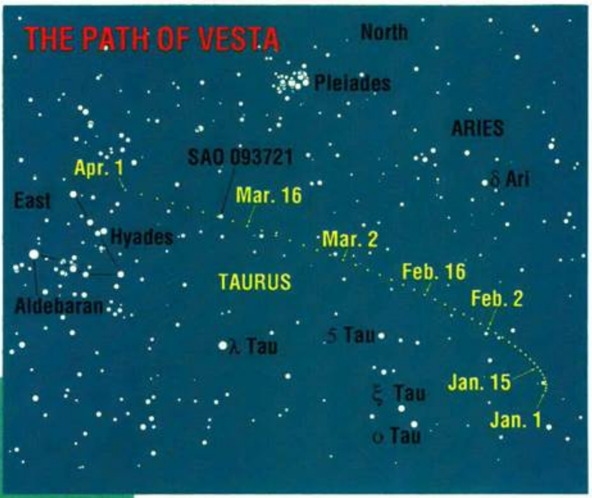
However, asteroids can be interesting targets on any night. The easiest to find are the "big four": Ceres, Pallas, Juno, and Vesta. Ceres is the largest, with an estimated diameter of 600 miles. In 1991, Ceres spends its time circling through the stars of Virgo. When it is at opposition (and nearest Earth) on April 17, it will be magnitude 7.0, an easy target for any telescope.

If you are lucky enough to witness the January 3 stellar occultation by Vesta, you may be inspired to follow this small world over the ensuing months. The finder chart shows Vesta's path across the winter and early spring sky as it moves through Taurus. On March 20, Vesta will glide past the star SAO 093721, coming within 3 arcminutes of this magnitude 5.9 star (though closest approach occurs in daylight hours for North America — by nightfall in North America, the two objects will be 12 arcminutes apart).

Pallas will be a springtime object moving north into Leo and then performing a wide turn to the east. The prime season for Juno will be this summer as it circles through southern Aquila. Finder charts for both these asteroids will be in ASTRONOMY's Sky Almanac department later this year.



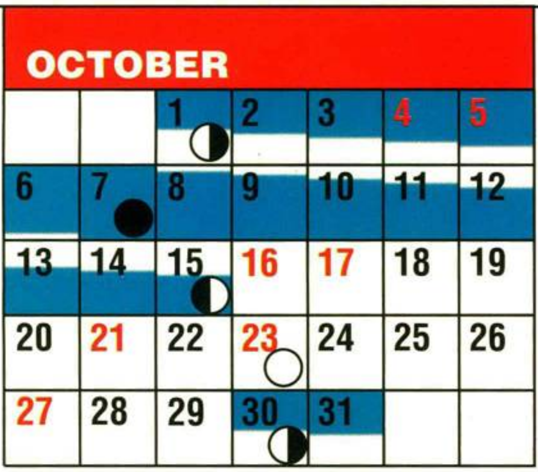
Positions are plotted for 11 p.m. EST (12 midnight EDT) at 2-day intervals



ASTEROIDS HIDING STARS IN 1991

(for North America)

Date	Hour (UT)	Asteroid	Mag. (astr.)	Star	Mag. (star)	Duration (sec.)	R.A. (2000)	Dec.
Jan. 4	0	4 Vesta	8.1	SAO 093228	8.0	143	2h59m	10°39'
Jan. 19	5	216 Kleopatra	11.7	SAO 115296	9.3	22	7h21m	1°05'
Jan. 26	4	34 Circe	11.4	LJ04514	10.1	12	8h43m	10°15'
Mar. 18	8	19 Fortuna	11.6	LJ00106	9.3	14	6h07m	21°38'
Mar. 30	6	2 Pallas	8.0	+06°1336	8.9	39	10h38m	6°29'
Apr. 11	3	4 Vesta	9.2	+20°0416	10.6	15	4h32m	20°08'
June 16	9	25 Phocaea	11.7	+20°2387	9.6	6	21h12m	20°24'
Dec. 12	9	22 Kalliope	10.7	+26°0444	11.5	14	4h47m	26°08'



OCTOBER

		1 ◑	2	3	4	5
6	7 ●	8	9	10	11	12
13	14	15 ◐	16	17	18	19
20	21	22	23 ○	24	25	26
27	28	29	30 ◑	31		

Day	**Hour** (UT)	
4	15	Venus occulted by Moon (Hawaii, Mexico's west coast)
5	05	Jupiter 5° north of crescent Moon (morning)
16	12	Saturn 2° south of First Quarter Moon
17	03	Venus 2° south of Jupiter (morning)
22	07	Orionid meteors peak (poor circumstances)
23	11	Full Moon — the Hunter's Moon
27	--	Fall back 1 hour to Standard Time

CLOSE ENCOUNTERS

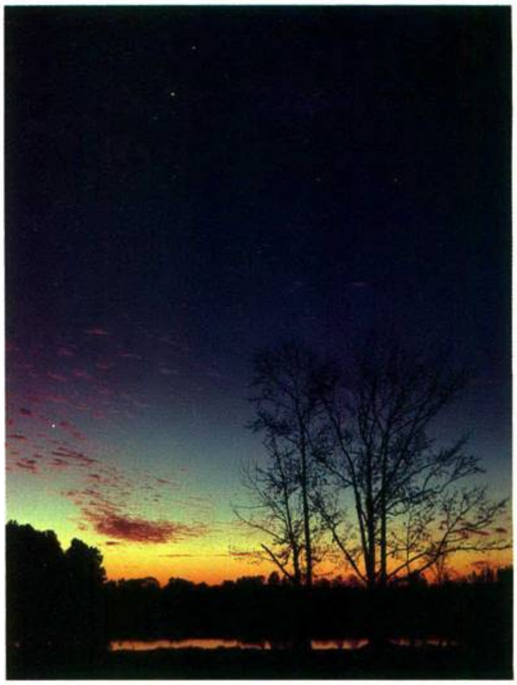
Some of the best astronomical shows of the year occur when several of the sky's greatest "stars" gather for an ensemble performance. And the price of admission can't be beat — free! You don't need a telescope to watch these events, though a binocular helps you get a front-row view.

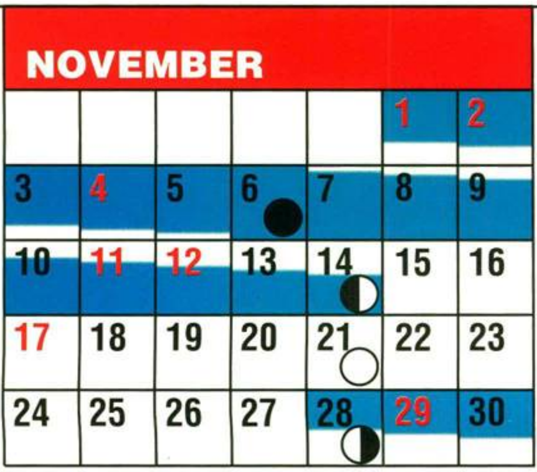
In 1991, a few evenings stand out as especially notable. On the night of January 24/25 the gibbous Moon, Mars, and the Pleiades will be close together. On January 29/30, the Full Moon, Jupiter, and the Beehive star cluster (M44) will form an interesting group, with the added attraction of a penumbral lunar eclipse the same night. From January to July, the crescent Moon will form a striking complement to Venus for several nights each month as it glides by the brilliant planet. Through the spring months, Venus will also be closing in on Mars and Jupiter, building to a final close encounter among the three in mid-June. Watchful observers may also catch sight of the very close conjunction of Jupiter and Mercury just after sunset on July 14 and July 15. But the duo will be only 3° or 4° above the western horizon. The two planets repeat the pairing in the eastern sky on the morning of September 10, with both planets close to the bright star Regulus. This fall, Venus and Jupiter repeat their August 1990 pairing when from October 14 to 18 the two brightest planets in the sky will be within 3° of each other.

CLOSE ENCOUNTERS IN 1991

Day	**Hour** (UT)	
JANUARY		
25	12	Moon occults Pleiades Cluster (Australia, Pacific)
	15	Mars 2° south of gibbous Moon
30	05	Jupiter 1.8° north of Full Moon & 1.5° south of M44
FEBRUARY		
7	--	Jupiter 1° south of Beehive Cluster (M44)
12	18	Saturn occulted by Moon (Hawaii, morning)
MARCH		
22	17	Mars occulted by Moon (Europe)
APRIL		
21	04	Mars 0.3° south of magnitude 3.0 star ε Geminorum
JUNE		
10	--	Uranus 1.8' south of magnitude 5.9 star SAO 187468
15	20	Venus, Mars, & Jupiter near crescent Moon (evening)
JULY		
14	16	Mars 0.7° north of Regulus (evening)
15	08	Mercury 4.8' south of Jupiter (evening)
27	--	Neptune 3.6' south of o Sagittarii
AUGUST		
11	07	Venus 3° south of thin crescent Moon (evening)
	08	Mercury occulted by Moon (Central Europe, Asia)
SEPTEMBER		
10	10	Mercury 4.2' south of Jupiter, 0.3° north of Regulus
OCTOBER		
4	15	Venus occulted by Moon (Hawaii, Mexico's west coast)
17	03	Venus 2° south of Jupiter (morning)

A TRIO OF PLANETS, Jupiter, Venus, and Saturn, graced the dawn sky in late 1980. This year, Jupiter, Venus, and Mars will gather in the spring evening sky.





NOVEMBER

					1	2
3	4	5	6 ●	7	8	9
10	11	12	13	14 ◐	15	16
17	18	19	20	21 ○	22	23
24	25	26	27	28 ◑	29	30

Day	**Hour** (UT)	
1	20	Jupiter 6° north of Last Quarter Moon
2	09	Venus at greatest western elongation (morning)
	21	Venus 6° north of Last Quarter Moon
4	--	Taurid meteors peak (good circumstances)
11	03	Uranus occulted by Moon (N. Australia, Hawaii)
12	22	Saturn 2° south of First Quarter Moon
18	03	Leonid meteors peak (poor circumstances)
29	08	Jupiter 6° north of Last Quarter Moon

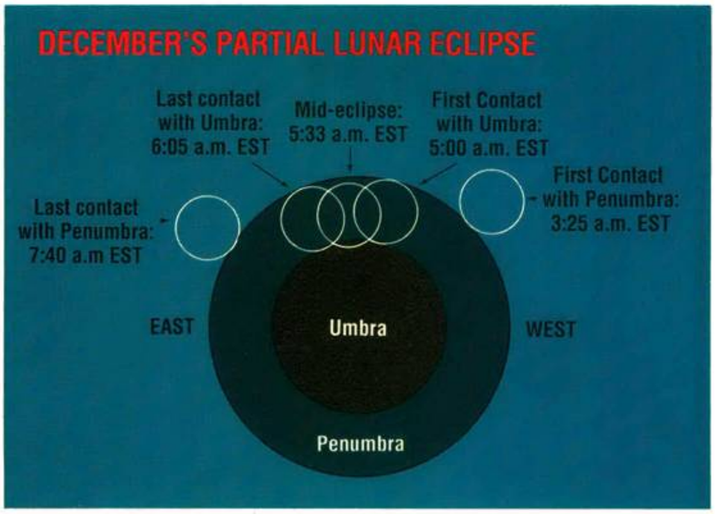
MOONSTRUCK

When it comes to the Moon, familiarity certainly breeds contempt. All too often the poor old Moon is dismissed as a rather uninteresting attraction, something that lights up the sky, washing out the fainter, more exotic deep-sky targets. But throughout each year the Moon can provide many nights of memorable viewing.

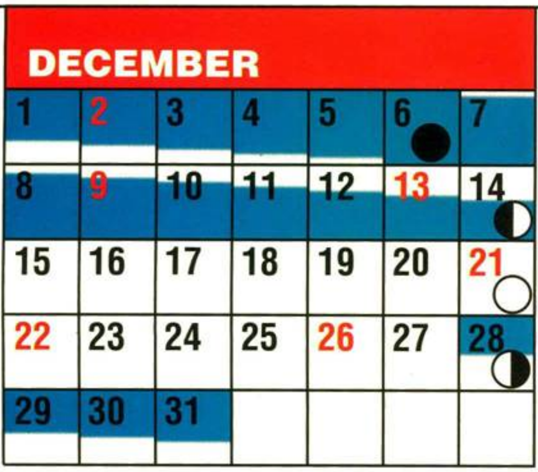
For example, during lunar eclipses everyone's attention turns to our satellite world. In 1991 there are four lunar eclipses, the maximum number possible in a year. Unfortunately, three are penumbral eclipses, which means the Moon passes only through the outer part of Earth's shadow. The darkening of the Moon's disk during these eclipses will be barely noticeable at best. In fact, the June 27 and July 26 events are partial penumbrals; you probably won't detect any trace of the eclipse at all! However, during the penumbral eclipse on the night of January 29/30 (visible from North America), you may be able to glimpse a slight darkening of the northern limb of the Moon. As a bonus, the Moon will also be near Jupiter and the Beehive Cluster that night.

On the morning of December 21, the Moon will once again glide through Earth's shadow, this time with the southern edge of the Moon just grazing the dark central portion of the shadow, the umbra. This partial umbral eclipse will be visible from North America in the predawn hours and at midnight from Hawaii and the Pacific. But don't expect too much — at mid-eclipse you'll see a mere nip taken out of the limb of the Moon. For a dramatic total eclipse of the Moon visible from all of North America we'll have to wait till November 29, 1993.

But if you are looking for a good lunar observing treat this year, try searching for the youngest Moon. How soon after New Moon can you see the sliver of the first crescent Moon? The record is 13 hours 24 minutes, but any sighting of a Moon younger than 24 hours is considered an accomplishment. For North American moonwatchers, March and May are the best months to glimpse a thin crescent Moon under 24 hours old. Of course, if you travel to the path of totality for July's solar eclipse, you'll be able to see the youngest Moon of all — 0 hours! — as it slides across the face of the Sun precisely at New Moon.


DECEMBER'S PARTIAL LUNAR ECLIPSE
Last contact with Umbra: 6:05 a.m. EST
Mid-eclipse: 5:33 a.m. EST
First Contact with Umbra: 5:00 a.m. EST
First Contact with Penumbra: 3:25 a.m. EST
Last contact with Penumbra: 7:40 a.m EST
EAST
Umbra
WEST
Penumbra

A SLIVER OF THE FIRST CRESCENT MOON is a challenging observing target. In November 1987 Larry Landolfi captured this 28.5-hour-old Moon.



DECEMBER

1	2	3	4	5	6 ●	7
8	9	10	11	12	13	14 ◐
15	16	17	18	19	20	21 ○
22	23	24	25	26	27	28 ◑
29	30	31				

Day	**Hour** (UT)	
2	14	Venus 8° north of crescent Moon (morning)
9	--	Saturn 3° south of crescent Moon (evening)
14	10	Geminid meteors peak (good circumstances)
21	10	Full Moon — partial lunar eclipse (N. America, Pacific)
22	09	Winter solstice — winter begins
26	17	Jupiter 7° north of Last Quarter Moon

Dark sky observing windows are indicated by the blue shading. At First Quarter Moon the sky is dark during the last half of the night after moonset. At Last Quarter the sky is dark during the first half of the night before moonrise.

Levy's Magnificent Comet

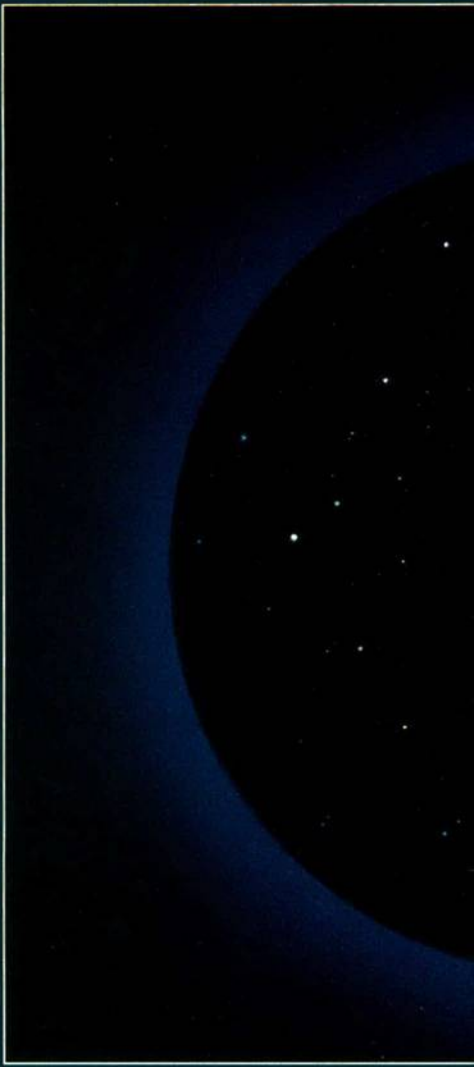
Backyard observers welcomed the first bright comet in many moons.

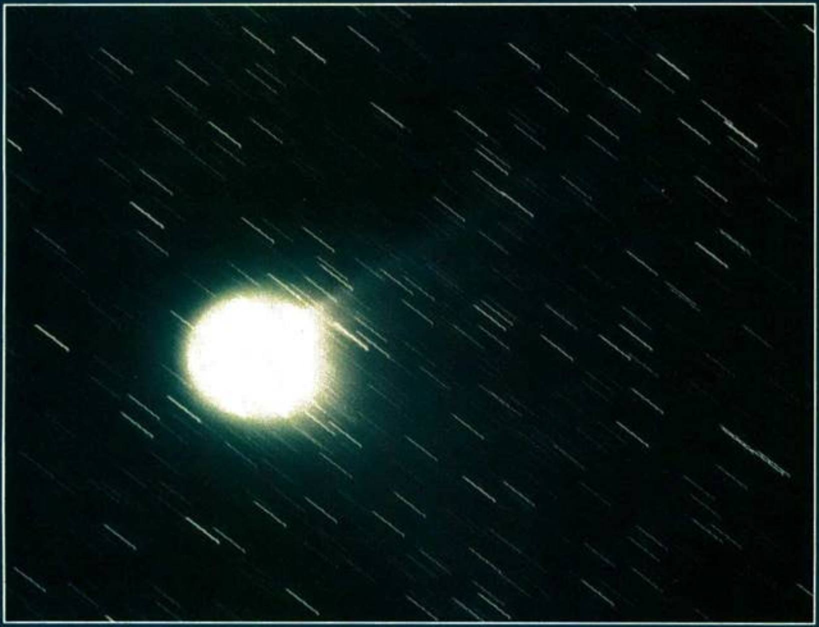
by David J. Eicher

"David, you'll never guess what's happened." These were the first words I heard as I entered the gate at the Texas Star Party in Fort Davis, Texas. It was May 21, 1990, and the well-known Arizona comet hunter David Levy was excitedly telling me about his latest comet discovery. "I found it from Tucson and confirmed it here last night." David had discovered five comets previously, and none had become really bright. So I held my excitement in reserve. But after viewing the comet and poring over the predictions, it became apparent that Levy's sixth comet would be a good one.

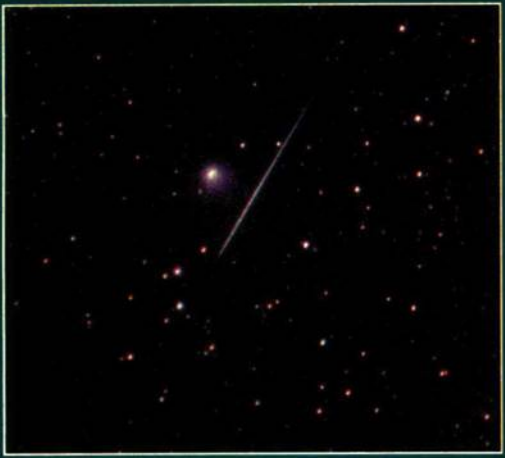
Comet Levy (1990c) resembled a big, bright ball of fuzz from the very beginning. At discovery it softly glowed between magnitudes 10 and 11 and seemed stuck southwest of Alpha Pegasi. Not long thereafter, astronomers calculated an orbit and reported Levy's comet was on the way in. The object would reach perihelion on October 24, 1990, and probably be best visible during the final days of August. By the first week of August, comet observer John Bortle of Stormville, New York, observed the comet with 10x50 binoculars and reported a magnitude of 6.1 and a short tail. After a long dry spell with many false starts, amateur astronomers knew they had a really fine comet.

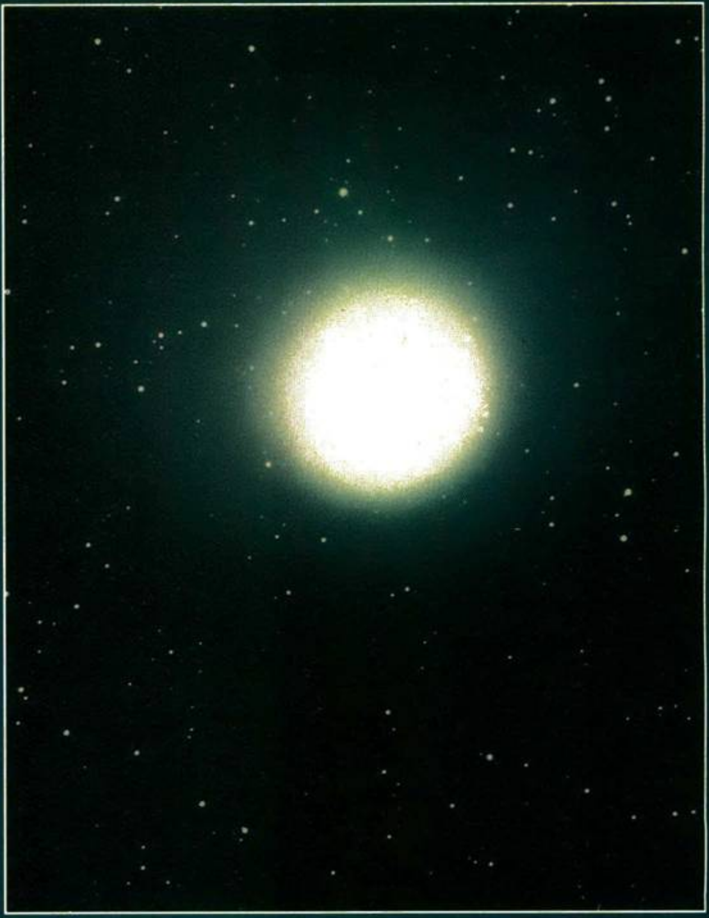
My impression of the comet as viewed with a 17.5-inch telescope on August 25 reminded me very much of the blobby, fast-moving comet IRAS-Araki-Alcock in 1983. Traces of tail were visible emanating from a bright, ball-like coma, and the entire ensemble was shrouded in a huge, faint, glowing envelope.





COMET LEVY'S BALL-LIKE COMA began to develop an ion tail during August 1990. Ronald E. Royer photographed the short tail on August 23 (left). One night later Michael Stecker recorded the comet's ruddy dust tail and light blue ion tail (above right). On August 18 Levy passed close by the bright globular cluster M15, dramatically showing how large and intensely bright the comet had become (right). Photo by Gerald Rhemann. Edwin Faughn of the Memphis Pink Palace Planetarium sketched Comet Levy on August 11 using a 6-inch reflector at 50x (above).





ON AUGUST 18 MICHAEL SANDRAS used a wide-field camera to photograph Comet Levy and also captured a bright meteor that whizzed by (top). Chris Schur's photo of the comet, made on August 17, typifies its appearance in small telescopes: a big, bright ball (right). The two photographs below show how amateurs used new technology to record Comet Levy. Steve McArthur of Spectra-Source recorded the comet with a Lynxx CCD camera and a 3.5-inch refractor on August 11 (below left). Richard Berry also used a Lynxx CCD camera for a 200-second exposure with a 6-inch f/5 reflector on August 29 (below right).

The comet's most striking feature was the intense, compressed nucleus that had an extraordinarily high surface brightness.

By August 25, hundreds of amateur astronomers had logged hours of Levy gazing. On July 23, James Foster of Hollywood, California, declared "the comet seemed to have a 1° or 2° tail and a highly condensed visible nucleus." One month later Foster said, "the comet has now developed a large, arclike ion tail that forks away from the main coma. It's visually the most interesting comet in ages." Arizona amateur Chris Schur described the comet on August 21 as "the best I've seen since Comet West in 1976."

Levy's comet slipped southward in September and was too close to the Sun for observation. However, we haven't seen the last of Levy yet: it will reappear in the evening sky in Hydra during the last week of February, still enticing binocular viewers at magnitude 7.

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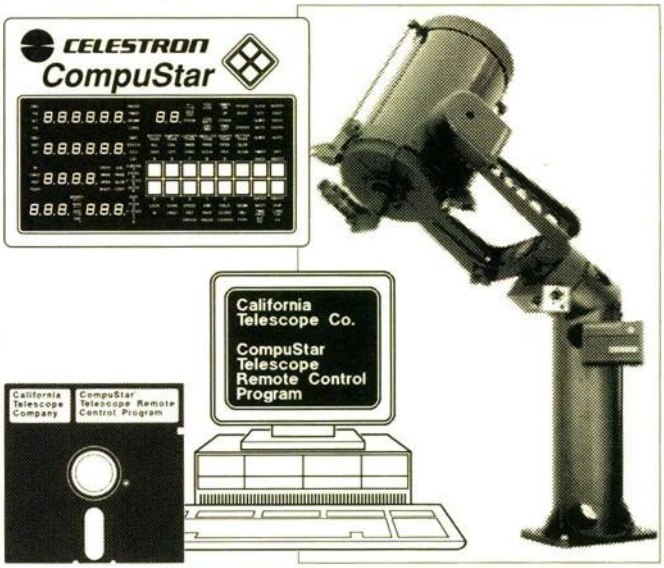
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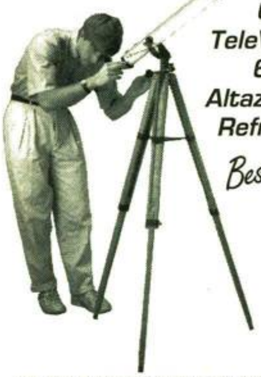

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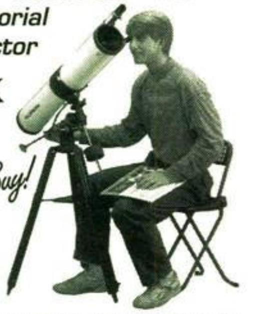

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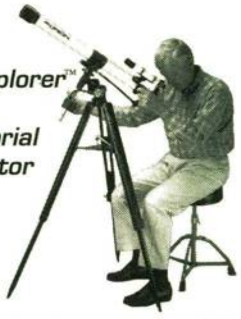

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The Sky Explorer's sturdy equatorial mounting is designed specifically for astronomy; it's ideal for lunar and planetary study, while providing good views of nebulas, star clusters, and double stars. By day, it's a powerful terrestrial telescope, great for nature study and scanning distant vistas.

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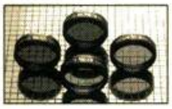

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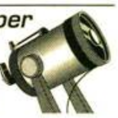

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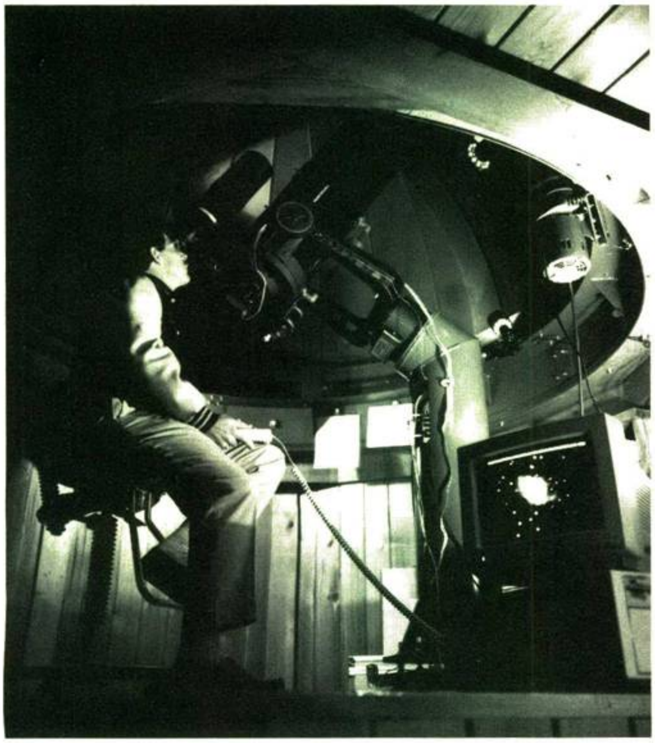

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INSTANT ASTROPHOTOGRAPHY

"Instant" may become astrophotography's watch word for the 1990s. In an era when people demand immediate gratification, traditional astrophotography puts off many newcomers because of the hard work involved and the long delay before seeing results. However, Los Angeles amateur Ben Mayer feels that super-fast films coupled with Polaroid cameras will help spark a surge in interest in astrophotography over the coming years.

"I took a number of photographs of Comet Austin near the Andromeda Galaxy during the last days of April 1990," says Mayer. "I used a standard Polaroid camera and that company's 20,000 ISO print film. New members at the Polaris Observatory Association couldn't believe what they saw — in the span of a few seconds we had a print showing the comet hovering near M31. They nearly fainted — from sky to photograph right before their eyes!

"This technique will be extremely important for astronomical discoveries," Mayer emphasizes. "Using instant photography and wide-angle lenses, amateur astronomers who want to search for comets or novae might cover large areas of sky in an hour or two. It could shift the balance of how these objects are found and observed."

Mayer has used high-speed photographic techniques and high-tech equipment for over 10 years, including cold cameras, hypersensitization, Schmidt cameras, and special tools for discovery like his PROBLICOM device. (PROBLICOM is short for Projection Blink Comparator.) He feels that Polaroid's high-speed instant photography is perhaps the most exciting of any of these processes because it brings astrophotography within easy reach of anyone who is interested.

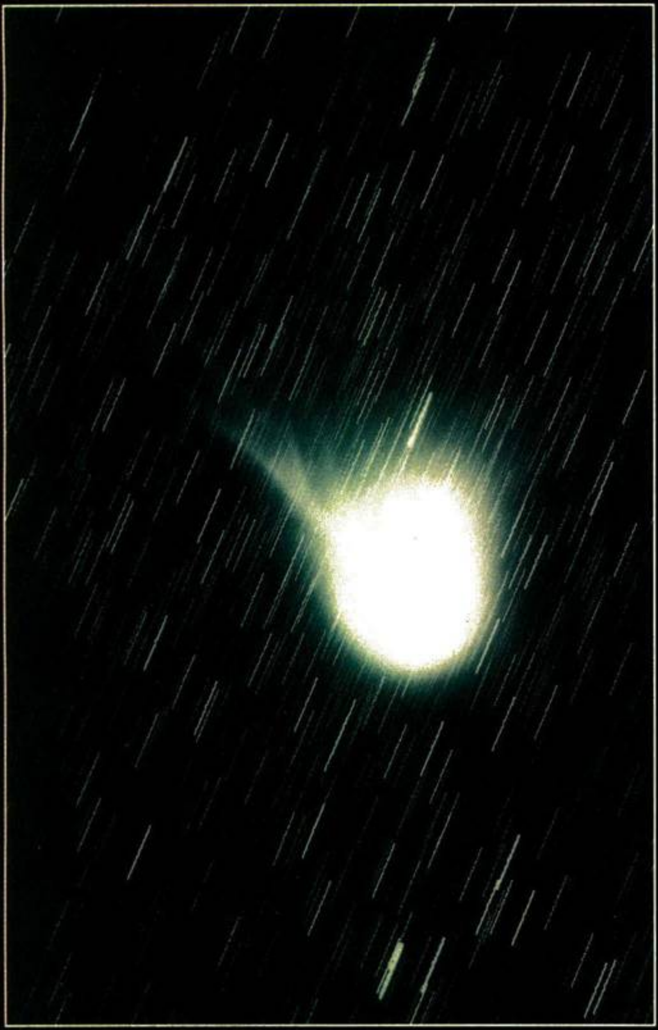
"Taking one or two or three photos in rapid succession is easy," he says. "Previously sophisticated areas of amateur astronomy will now be within reach of relative newcomers. What could possibly be more exciting?"

INSTANT ASTROPHOTOGRAPHY is now within reach of amateurs: a 30-second unguided exposure on Polaroid 20,000 ISO film with just a camera and tripod captured the Andromeda Galaxy and Comet Austin on April 28, 1990. (The comet is faintly visible above the dome; the galaxy left of the dome). A 10-minute guided exposure on PolaPan 35mm 125 ISO color film shows an even greater amount of detail (left). Photos by Ben Mayer.

DEEP-SKY CHALLENGES: CENTRAL STARS AND GALAXY CLUSTERS

What objects offer the greatest challenge to deep-sky observers? For Bryce Heartwell of Calgary, Alberta, Canada, the answer is the central star in M57 and faint galaxy clusters.

"The challenge object highest on my

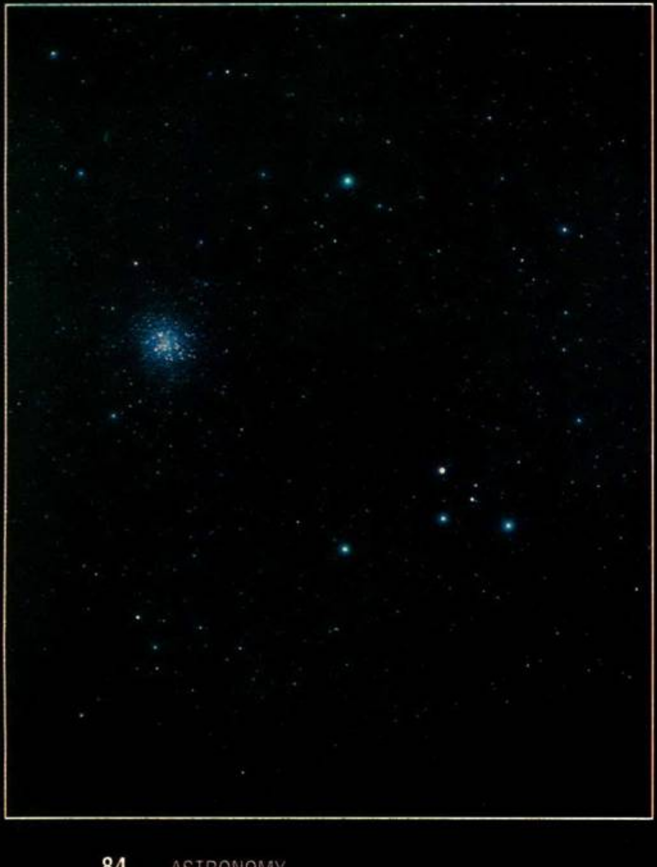


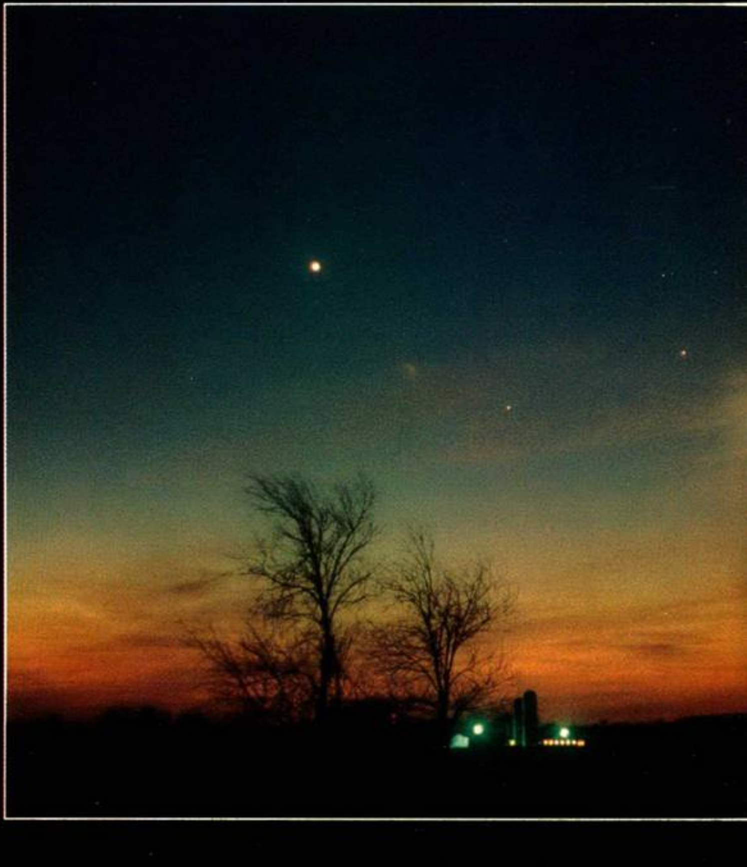
RESTLESS SUN PUTS ON DELIGHTFUL SHOW

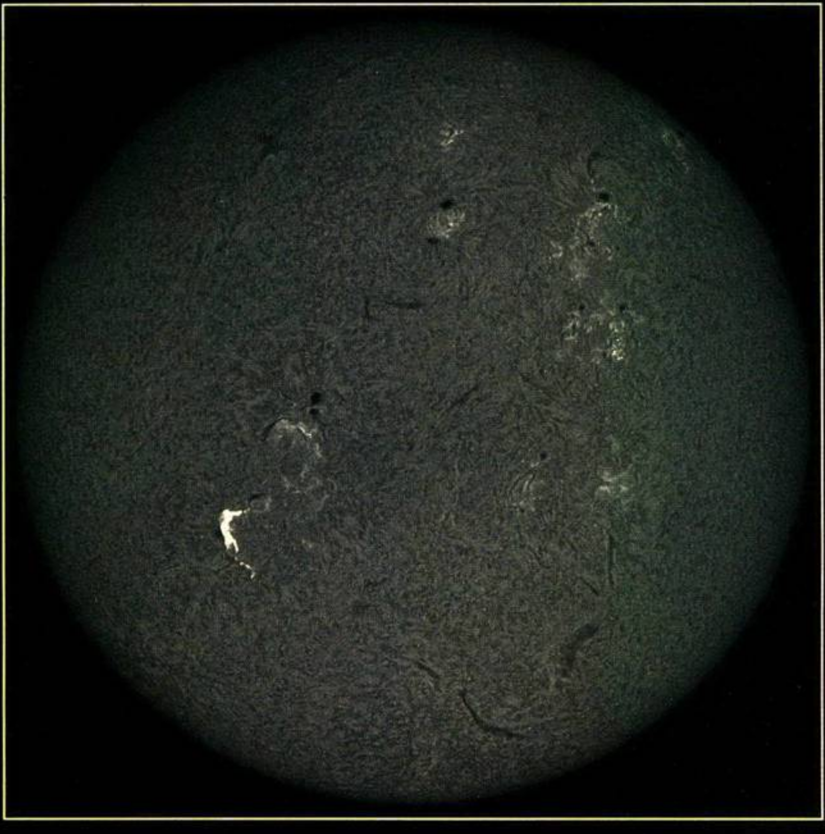
The Sun kept observers transfixed throughout the summer of 1990 as it underwent an eclipse, displayed large numbers of sunspot groups, and produced huge solar flares. Steven Nehl's photograph of the July 21 eclipse paired with Seattle's Space Needle (right) wins this month's $100 "Best Astrophoto" award. Nehl used a 600mm lens at f/16, Ektar 400 film, and a 1/100-second exposure. On July 4 Brian Day recorded an impressive solar flare (opposite, below right).

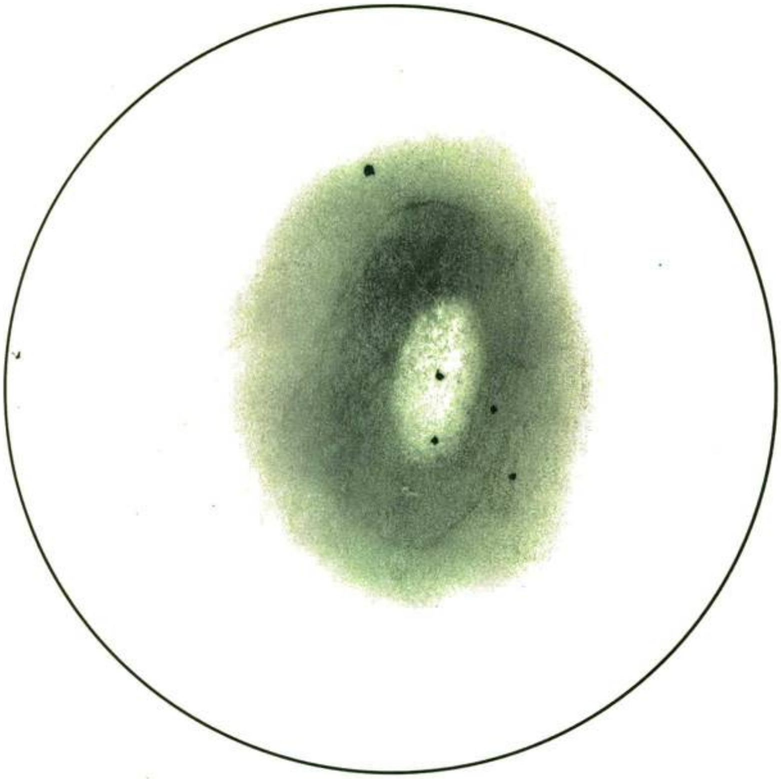
In the early morning of February 21, 1990, Janet Lindemann of Elkhorn, Wisconsin, captured an amazing grouping of planets in the predawn sky (below). Her photograph shows Venus, Saturn, Mars, and the Moon among the stars of Sagittarius. On August 31, 1990, Texas astrophotographer J.R. Swartz captured tiny, blue-green Uranus as it swept past globular cluster M22 (below left). The planet is the bright "star" above and to the right of the cluster.

Comet Levy continued to attract observers as it hung low in the evening sky during August. Los Angeles amateur Michael Stecker's photo was made on August 24 and shows the comet's bright coma and thin ion tail (left).









HIGH POWER AND STEADY SEEING enabled Canadian observer Bryce Heartwell to sketch four stars involved in the Ring Nebula (M57). Heartwell used a 14.3-inch f/4 reflector at 434x.

list is the Corona Borealis Galaxy Cluster," says Heartwell. "In August 1990 I hauled out my 14.3-inch f/4 reflector and went after this notoriously difficult group.

"Last year I went after this object and spotted four galaxies," Heartwell continues. "On vacation in the U.S., however, I was much more successful. One night from Arizona's Kaibab National Forest, located north of the Grand Canyon, I spotted twelve galaxies in the cluster. Each was a difficult object to spot in the 14-inch scope at 291x. Two were steady with averted vision, and the others fainter still.

"I also conquered the elusive central star in the Ring Nebula last August," says Heartwell. "On May 26 I was able to use 434x because the night was very steady. The central star popped into view for periods of four or five seconds. Although it was a difficult observation, I could clearly see the central star during moments of steady seeing. After all I've read about the difficulty of seeing this star I hadn't imagined it would be visible in my telescope. It was something I'll never forget and certainly ranks as one of the greatest thrills of my deep-sky observing experience." — *David J. Eicher.* □

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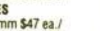

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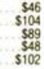

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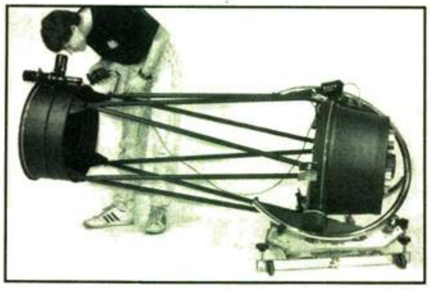


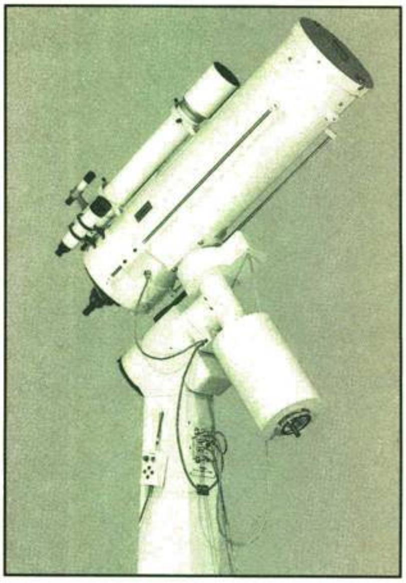
3

NGT-16 telescope

The *NGT-16* is a 16-inch Newtonian on a split-ring equatorial mount. Its serrurier truss rod design allows the entire telescope to be collapsed for transport in a compact station wagon. The manufacturer claims that one person can assemble the telescope in under five minutes. The *NGT-16* uses Galaxy Optic's Ultimate Image series primary and secondary mirrors. Standard features include a 2-inch, low-profile focuser, an 8x50 Polaris finderscope, a rotating nose assembly, an adjustable focal point for visual and photographic applications, and an 18-point mirror flotation. A drive corrector, a rechargeable power supply, a cooling fan, and digital setting circles are available as options. An 18-inch model, the *NGT-18*, is also available. For a catalog and sample NGT astrophotographs, send $3.00 to Jim's Mobile Industries.

Jim's Mobile Industries, 1960 County Road 23, Evergreen, CO 80439; (303) 277-0304; FAX (303) 526-9140. NGT-16: $7,400.00.

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.

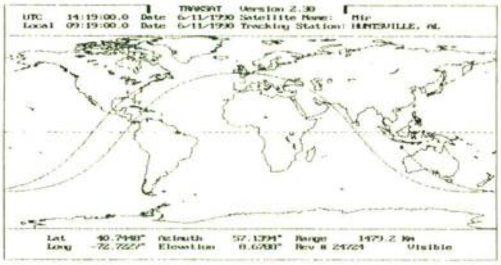


2

ASKO 10.2-inch Cassegrain Telescope

A new 10.2-inch Cassegrain, manufactured by ASKO of Japan, is now available exclusively through R.V.R. Optical. R.V.R. also offers a complete line of custom-built telescopes from 8¼-inch to 40-inch aperture, as well as a line of Schmidt cameras and photo-visual Wright Schmidt cameras up to 20-inch aperture. A catalog with complete information is available for $5.00.

R.V.R. Optical, P. O. Box 62, Eastchester, NY 10709; (914) 337-4085.



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                 TRAKSAT   Version 2.30
UTC    14:19:00.0  Date  6/11/1990 Satellite Name:   Mir
Local  09:19:00.0  Date  6/11/1990 Tracking Station: HUNTSVILLE, AL

Lat    40.7448°  Azimuth     57.1394°  Range     1479.2 Km
Long  -72.7227°  Elevation    0.6780°  Rev # 24724        Visible
```

4

TRAKSAT Satellite Tracking Software

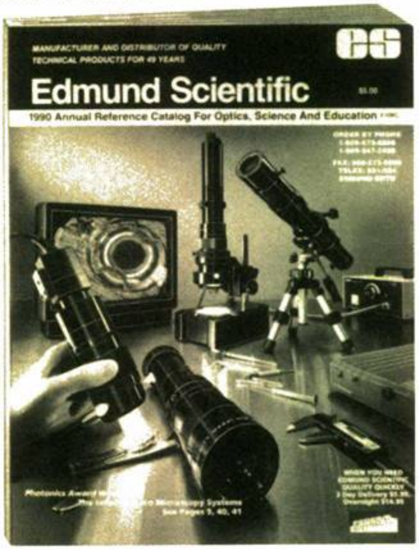
TRAKSAT is a new "shareware" satellite tracking program for amateur radio enthusiasts and optical satellite trackers. The program can read standard NASA/NORAD orbital elements available in ASCII-format from several computer bulletin boards around the United States (some bulletin boards are listed in TRAKSAT's documentation). The program has two graphics modes: a sky view shows the satellite's path across the night sky as seen from your location, while an orthographic view shows the orbital track about the Earth as seen from a point in space. TRAKSAT can also identify unknown satellites from three satellite observations. A 60-page manual accompanies the program. TRAKSAT requires an IBM XT, AT, PS/2, or compatible with a minimum of 640K memory. The manufacturer recommends a hard disk, numeric coprocessor, and VGA graphics.

TRAKSAT, c/o Paul E. Traufler, 111 Emerald Drive, Harvest, AL 35749; (205) 726-5511. $10.00

5 New Edmund Scientific Catalog

The new 1991 Edmund Catalog features more than 7,000 optical and industrial products. Included is a complete line of telescopes, microscopes, magnifiers, lab equipment, optical components, and hard-to-find accessories. The 188-page catalog is free on request.

Edmund Scientific Company, Dept. 10B1, N999 Edscorp Building, Barrington, NJ 08007.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6 Improved Binoc-U-Mounts

The Innovative Energies line of binocular-to-tripod mounts has been upgraded and now features an interior covering of suede instead of vinyl to improve the grip. In addition, the straps that fasten over the top of the binocular are now made of an acrylic weave instead of a stretch fabric for a more secure hold. A longer Velcro strip is now sewn into the straps for a solid lock over a wider range of binocular sizes. Three sizes of *Binoc-U-Mounts* are available: the *Compact* for small binoculars, the *Silhouette* for sport and astronomical sizes, and the *Copernicus* for large 70mm and 80mm aperture binoculars.

Innovative Energies, 50 Tower Road, Newton, MA 02164; (800) 542-7771. Compact: $29.00; Silhouette: $35.00; Copernicus: $39.00.

7 New Mirror-Making Kits

Palomar Optical Supply now offers a full line of mirror-making kits. Each kit features a fine annealed Pyrex mirror blank, a plate glass tool with a molded f/8 convex curve, a complete set of grinding and polishing compounds (each stored in resealable plastic bottles), and a supply of rosin for making a pitch lap. Kits are available for 4¼-, 6-, 8-, 10-, 12.5-, and 16-inch mirror sizes. All orders, except those for 16-inch kits, are shipped postpaid in the continental United States. Palomar Optical also offers abrasives and polishing compounds separately in a variety of quantities. Write for a complete price list.

Palomar Optical Supply, P. O. Box 1310, Wildomar, CA 92395; (714) 678-5393. 4¼-inch kit: $45.50; 6-inch kit: $58.75; 8-inch kit: $93.75; 10-inch kit: $199.50; 12.5-inch kit: $329.00; 16-inch kit: $490.75.

8 Minolta Infinium Planetarium

Designed for tilt domes of 20 to 25 meters in diameter, the *Infinium Planetarium* uses a single star ball that projects up to 23,000 stars down to magnitude 7.4. The optical projection system uses a single light source with a new high intensity/low temperature design. Ten separate projectors are used for the 21 brightest stars. The *Infinium's* seven planet projectors, plus an Earth/Moon projector, are independent of the main star ball. Their computerized control system allows the *Infinium* to show the motion of the planets from any vantage point in the solar system. The first *Infinium* in the United States is being installed at Broward Community College in Florida.

Minolta Planetariums, c/o Bergelt Litchfield Raboy & Tsao, Inc., 345 Hudson Street, New York, NY 10014. Contact Andrew Armstrong, Minolta Account Supervisor for more information. □

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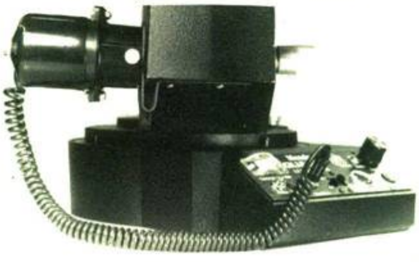

Motor is equipped with variable speed control. These motors are designed for use with manufacturer's hand unit, or drive corrector - if you have neither, they may be ordered with a hand control (add $10).

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LX5	**1,2,3,4,5,6,9**
LX6	**1,2,3,4,5,6,9**
DS10	**1,2,3,4,5,7**
DS16	**1,2,3,4,5,7**
2040	**1,2,3,4,7**
2045	**1,2,3,4,6.7**
2045D	**1,2,3,4,6**
2080/2120 GEM	**1,2,3,4,5,6,8**
6600/8800	**5,6,8**
295/310/320	**5,6,8**
628/645/826/856	**1,2,3,4,5,7**
880/1060/1266	**1,2,3,4,5,7**
2080/2120 MTS	**1,2,3,4,5,6**
6600/8800 MTS	**1,2,3,4,6**
CELESTRON	
C-8/Super C-8	**1,2,3,4,5,6,7**
C-11	**1,2,3,4,5,6,7,9**
C-14	**1,2,3,4,5,6,9**
Ultima 8*	**1,2,3,4**
Ultima 11*	**1,2,3,4**
Super Polaris C-8	**1,2,3,4,5,6**
SPC-90/SPC-102	**1,2,3,4,5,6**
Polaris C60/C70/C80/C100	**5,6**
Polaris C-6/C-125	**6**
Polaris C-4.5	**5,6**
C-5	**5,7**
Powerstar* (all)	**1,2,3,4**
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with 2" Focuser	**1,2,3,4,5,6**
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Bausch & Lomb	
B&L 4000	**1,2,3,4,5,6,7**
B&L 8000	**1,2,3,4,6,7**
Dynamax	
Dynamax 8	**1,2,3,4,6,7**
Questar	
Questar 3.5	**1,2,3,4**
Takahashi	
EM-200	**1,2,3,4**
All but TSC	**5**
TeleVue	
Genesis, TVS	**1,2,3,4,5,6**
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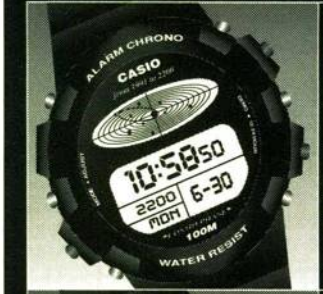

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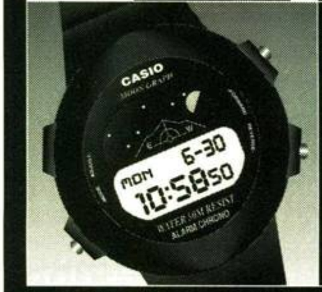

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Orion MegaVista 16.8mm and 10.5mm eyepieces, (Orion Telescope Center, 2450 17th Avenue, P.O. Box 1158, Santa Cruz, CA 95061; (800) 447-1001). List price: $119 (16.8mm) and $109 (10.5mm).

Takahashi LE-50 50mm eyepiece, (Land Sea & Sky/Texas Nautical Repair Co., 3110 S. Shepard, Houston, TX 77098; (713) 529-3551). List price: $296.50.

The Orion Telescope Center introduced their MegaVista eyepieces about a year ago. They come in two focal lengths — 16.8mm and 10.5mm — placing these models in the medium power range. We estimated that the 16.8mm has an apparent field of view of about 67°, very close to the advertised 70° field. The 10.5mm had a slightly smaller field, about 64° to 65°. Both eyepieces use a 7-element lens design, have a 1-1/4-inch barrel threaded for filters, and come with built-in rubber eyeguards. We measured the eye relief as a generous 14mm for the 16.8mm model and a 10mm for the higher power 10.5mm model, an excellent figure for an eyepiece of this focal length. The two eyepieces are not quite parfocal; you need to refocus slightly when switching between the two.

The optical quality of both eyepieces was impressive. I expected to see mushy stars just a few degrees off axis and wildly astigmatic stars at the edge, a common trait of many run-of-the-mill wide-angle eyepieces. Instead, with the 10.5mm, stars started to flare out 65 percent of the distance from the center to the edge, leaving a very generous aberration-free field in the center. Even at the extreme edge, aberrations from astigmatism and lateral color were very low and noticeable only on the brightest stars. The 16.8mm model boasted a similar performance but astigmatism set in about 50 percent of the way out from the center and became slightly greater at the edge than in the 10.5mm model. However, I would still rate its performance as very good. Neither eyepiece showed noticeable ghost images when looking at bright objects like stars and planets. This is remarkable in a multi-element eyepiece and shows the benefit of good multi-coating on all air-to-glass lens surfaces. Both eyepieces also exhibited excellent freedom from scattered light when a bright object such as the Moon was just outside the field.

The 16.8mm weighs 9 ounces and the 10.5mm weighs only 7 ounces. Their light weight, compact size, and 1-1/4-inch barrel diameters make them easy to use on most telescopes. At just over $100 each, the MegaVistas provide what I consider to be an excellent value in a wide-angle eyepiece, with a level of performance equal to or surpassing other premium eyepieces with fields of 65° to 70°.

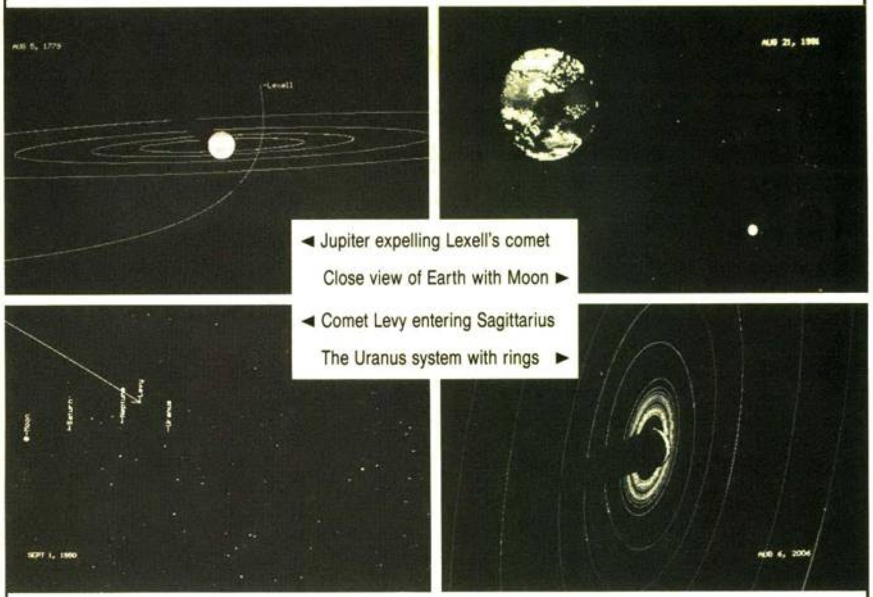
The Takahashi 50mm eyepiece with its 2-inch barrel diameter is in the ultra-low power league. We estimated its field of view as approximately 50°. On any given telescope, the Takahashi (and any 50mm 50° model) gives the same *actual* field as a 40mm 65° wide-angle eyepiece, with both types of eyepieces providing the widest field of view possible in a 2-inch barrel size. An eyepiece with a focal length of 50mm is most useful on telescopes with an f/ratio of f/7 or longer. When used on faster telescopes a 50mm eyepiece would yield an exit pupil greater than the maximum recommended 7mm, the size of the dark adapted pupil.

The performance of the Takahashi was excellent. According to the distributor, it uses a 5-element design similar to an Erfle. All air-to-glass surfaces appear to be multi-coated and ghost images were negligible. Slight astigmatism started about 60 percent of the distance from center to edge. At the very edge, astigmatism was still very well suppressed, providing aesthetically pleasing low-power views of star fields. While the Takahashi did not provide pinpoint stars right to the edge, we have yet to find any eyepiece in this focal length range that does, and certainly none that surpass the Takahashi in this regard.

The Takahashi has a rubber grip ring and a giant rubber eyeguard that is actually a collapsing hood made for a camera lens. The barrel is threaded for 2-inch filters. The 1 pound 4 ounce weight and 5-inch height make this a sizable and hefty eyepiece. However, it weighs 4 to 10 ounces less than 40mm wide-angle models such as Meade's and TeleVue's and provides the same actual field of view. At $296 the Takahashi is about the same price as a Meade or TeleVue 40mm wide field model but is more expensive than competitive 45 to 55mm Plössl models. If you have an f/7 or slower telescope and are looking for a maximum field-of-view observing "window" for your scope, I can recommend the Takahashi as a superb, though high-priced, choice.

— *Alan Dyer* ☐

DANCE OF THE PLANETS™ 2.0



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Close view of Earth with Moon ►
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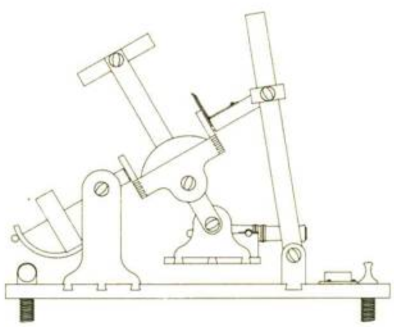

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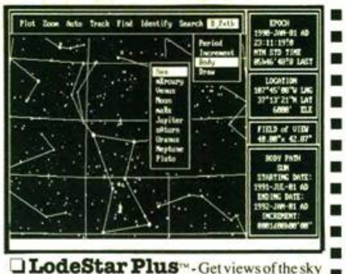

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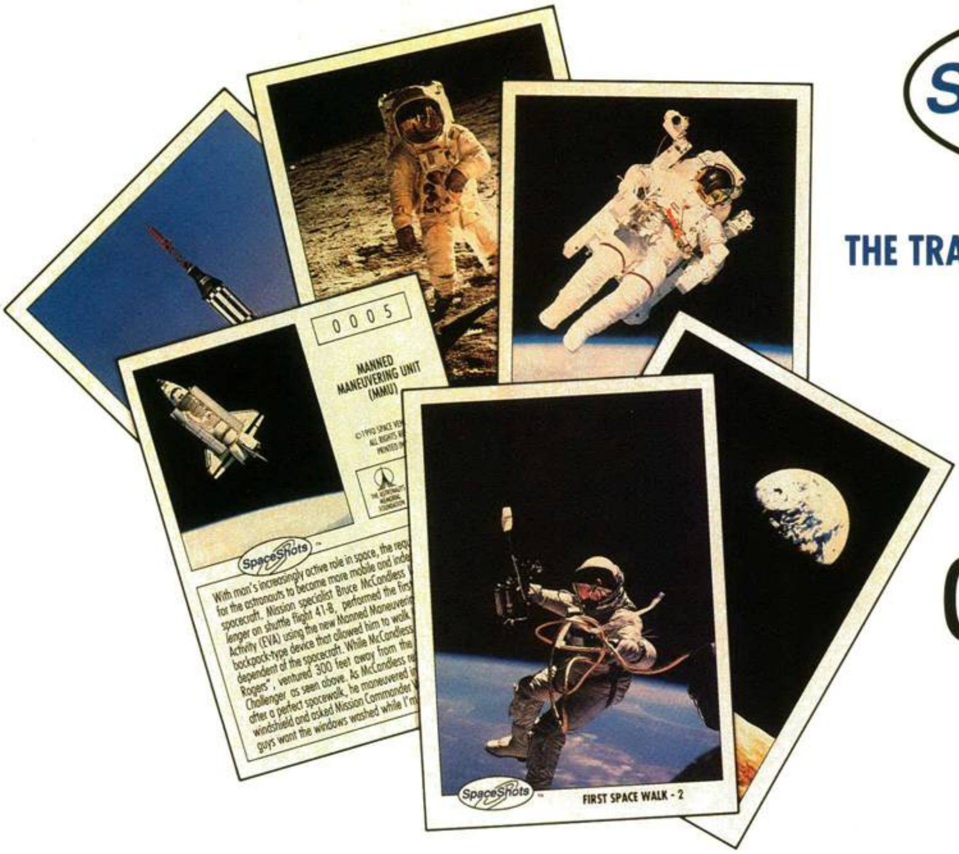

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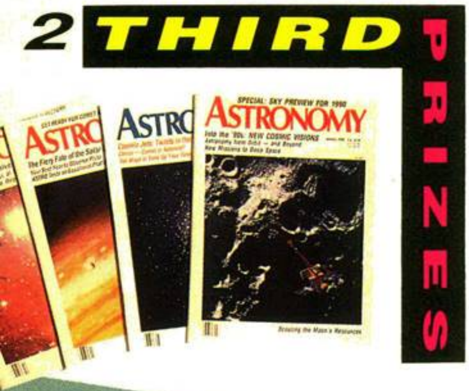

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2. Entries are limited to one per person per month. To be eligible for monthly prize awards, entries must be postmarked by the final day of the preceding month, i.e. November 30 for the December drawing. Monthly prizes will be selected in December 1990, January 1991 and February 1991. All entries must be postmarked by January 31, 1991. The Grand Prize will be awarded in February 1991. Monthly prize winners will become ineligible for future monthly awards, but will be eligible to win the Grand Prize. All entries qualified under these rules will be eligible for the Grand Prize.
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Astronomy Books

SUPERNOVA 1987A IN WORD AND PICTURE

End in Fire, by Paul Murdin, (Cambridge University Press, 1990), ISBN 0-521-37495-2, 237 pages, hardcover, $27.95.

Royal Greenwich Observatory astronomer Paul Murdin has put together a superlative book on the current state of knowledge about Supernova 1987A. This supernova in the Large Magellanic Cloud was the first naked-eye supernova in more than 380 years, and it gave astronomers a golden opportunity to study in great detail such a rare celestial event.

Since February 24, 1987, dozens of professional astronomers have probed SN 1987A with the most sophisticated astronomical equipment, which has included airborne telescopes and electronics, underground tanks of water, radio and optical telescopes, and satellites. Except for the Sun, SN 1987A is probably the most studied star in history. This book covers the vast array of research that has been done since SN 1987A appeared on the scene.

Murdin tells of the confusion during the first few hours after the discovery of the supernova by Ian Shelton at the Las Campanas Observatory in northern Chile. Then in a clear and non-technical way, Murdin explains what we have learned about the star, a blue supergiant that exploded 170,000 years ago in the Large Magellanic Cloud but whose flare of light reached us only now.

SN 1987A put to the test many astrophysicists' theories: on neutrinos, x-rays, gamma-rays, and other aspects of atomic physics. Most of the theories passed, but others will have to wait until we can see how the supernova's remnant develops.

One of the interesting puzzles the author covers has to do with the existence (or not) of a circumstellar shell around the supernova. This has been found recently by *Hubble Space Telescope* observations (see AstroNews, December 1990), but at the time of Murdin's writing, of course, the shell was invisible. However, he outlines the speckle interferometry techniques astronomers used to remove the distorting effects of astronomical seeing. This led to the discovery of an object 0.6" (18 light-days) away from SN 1987A. Known as the Mystery Spot, this object has not been seen since its discovery in March 1987. What is — or was — the Mystery Spot? Murdin discusses a few of the theories and explanations, and in passing leaves the reader in no doubt that unraveling the complex story of the supernova will take a long time.

This is a very entertaining and informative book. I recommend it highly.
— Robert A. Garfinkle

QUICK PICKS

Observing

The Amateur Astronomer, by Patrick Moore, (Norton, 1990), ISBN 0-393-02864-X, 337 pages, hardcover, $35.00.

First published in 1957 and regularly revised, Moore's *The Amateur Astronomer* has been reissued in a new edition that brings it up to date. Long known for its direct, almost quirky style, the book is an enjoyable and thorough introduction to backyard astronomy. (One drawback: despite the heavy use the book will probably get, its binding is merely glued, not sewn, and some pages will come loose eventually. This is a shame, given its fairly steep price.)

The Monthly Sky Guide, by Ian Ridpath and Wil Tirion, (Cambridge University Press, 1990), ISBN 0-521-38665-9, 64 pages, paperback, $10.95.

This new edition of a work first published in 1987 is updated to include the monthly locations of the naked-eye planets for 1990 to 1994. The remainder of the book provides a good introduction to stars and constellations and to amateur observing by eye and with a small telescope.

Seeing the Sky, by Fred Schaaf, (John Wiley & Sons, 1990), ISBN 0-471-51067-X, 212 pages, paperback, $12.95.

Subtitled "100 projects, activities, and explorations in astronomy," Fred Schaaf's book would make an excellent and easy-going, if unconventional, introduction to astronomy for novices. The projects range from simple ones such as sketching the naked-eye appearance of the Full Moon to tracking the changes in variable stars.

Teach Your Child Science, by Michael Shermer, (Lowell House, 1989), ISBN 0-929923-08-1, 149 pages, paperback, $9.95.

Shermer's basic premise is that every kid is a born scientist, but most soon have their curiosity rubbed away by school and social pressure. His book is a how-to guide for any parent who wants to preserve and foster that curiosity. It provides good advice and sensible projects for the child to do on his or her own and in company with the parent (the subtitle is "making science fun for the both of you").

Astronomical History

The Poetic Structure of the World: Copernicus and Kepler, by Fernand Hallyn, (MIT Press, 1990), ISBN 0-942299-60-4, pages, acid-free paper, hardcover, $23.95.

Deconstruction, a French lit-crit flu that's sending a high fever through most English departments these days, has finally discovered astronomy. "The most profound poetic change from Ptolemy to Copernicus concerns astronomy's *telos,* its ironic or anagogic schemas for appraising value." And: "Kepler's texts are impregnated with a cosmogonic *semiosis.* They present the universe as a collection of signs that concretize ideal transcendencies."

That conveys pretty well the author's style. But for this reader at least, those sentences — excuse me, *texts* — simply rehash what historians of astronomy have said for decades, that Copernicus wasn't interested in Ptolemy's kind of mathematical games; he wanted to show how the universe *is.* And Kepler, a driven mystic, saw in the heavens the embodiment of abstract geometrical forms.

Well, so what? Those ideas can be found in any history of astronomy. Does Professor Hallyn expect our applause because, having made such heavy weather of it, he comes into port at last with some commonplaces of astronomical history? Life's too short to be patient with a book that wraps so many obvious points in such clotted jargon.
—Robert Burnham

Astronomer by Chance, by Bernard Lovell, (Basic Books, 1990), ISBN 0-465-00512-8, 381 pages, hardcover, $24.95.

This is a compelling autobiography by the radio/radar astronomer who built the 250-foot radio telescope and observatory at Jodrell Bank, England. It is especially strong in drawing a picture of what it was like to be a scientist in the decades immediately after World War II.

Stars

Properties of Hot Luminous Stars, edited by Catharine Garmany, (Astronomical Society of the Pacific, 1990), ISBN 0-937707-24-4, 362 pages, hardcover, $32.

Cool Stars, Stellar Systems, and the Sun, edited by George Wallerstein, (Astronomical Society of the Pacific, 1990), ISBN 0-937707-27-9, 523 pages, hardcover, $32. ☐

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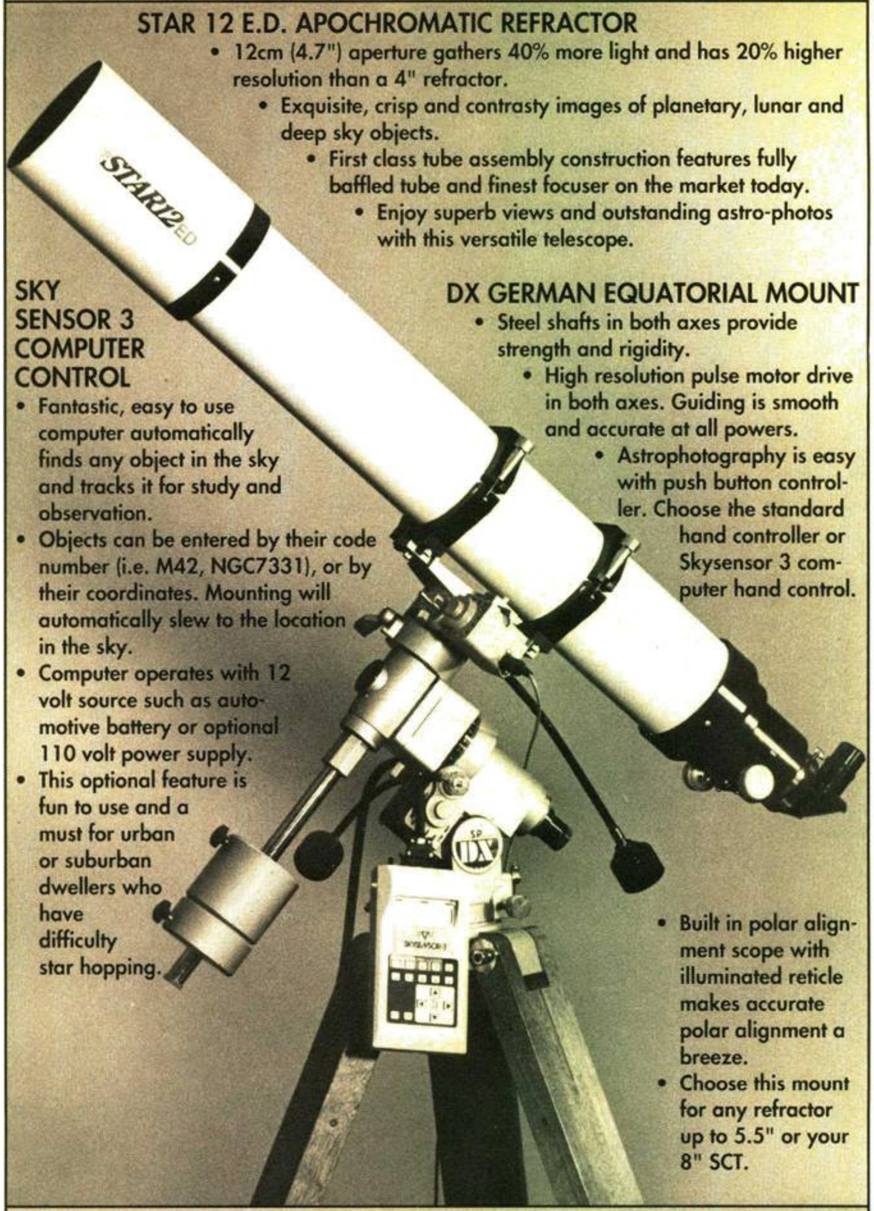

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February 14-18
7th Annual Winter Star Party, Florida Keys, Florida. Contact: Bob or Sharon Grant, 5401 Southwest 110th Avenue, Miami, FL 33165. Phone: (305) 595-8778. □

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Readings and Resources

The Star that Breaks the Rules (page 28)

"The Rapidly Rotating Spotted Red Dwarf Star Gliese 890" by B. R. Pettersen *et al.*, in *Astronomy and Astrophysics*, **183**: 66 (1987). In this paper a group of European astronomers outlines its discovery of the flares associated with Gliese 890.

"The Rapidly Rotating Field M Dwarf Gliese 890" by Arthur Young *et al.*, in the *Third Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun*, edited by Sallie L. Baliunas and Lee Hartmann (Springer-Verlag, 1984). This book contains a thorough, technical review paper on the state of knowledge on Gliese 890 through the early 1980s.

Magellan Unveils Venus (page 34)

"The Geology of Venus" by Alexander T. Basilevsky and James W. Head in the *Annual Review of Earth and Planetary Sciences*, Volume 16, 1988. An excellent review paper describing the state of knowledge on Venusian geology prior to *Magellan*'s arrival.

Magellan: Mission to Venus, (Martin Marietta Astronautics Group, 1990). An introductory booklet describing the overall specifications and objectives of the mission.

Stand in the Shadow of an Asteroid (page 54)

"Measuring the Shape of an Asteroid" by Paul Maley, ASTRONOMY, February 1984 . A report on the results of the 1983 Pallas occultation.

"Chasing Moon Shadows" by David Dunham and Donald Stockbauer, ASTRONOMY, October 1984 . If occultations interest you this article will tell you about a related phenomenon — grazing occultations of stars by the Moon.

1991 Sky Guide (page 64)

Observer's Handbook 1991, edited by Roy Bishop, (Royal Astronomical Society of Canada, 136 Dupont Street, Toronto, Ontario, Canada M5R 1V2). A comprehensive 230-page annual guide to celestial events. A must-have volume for many astronomers.

Astronomical Calendar 1991, edited by Guy Ottewell (Astronomical Workshop, Furman University, Greenville, SC 29613). A large format popular guide to the 1991 sky. Illustrated with well-executed diagrams.

CREDITS

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ASTRONOMY

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AVAILABLE ON YOUR NEWSSTAND JANUARY 8

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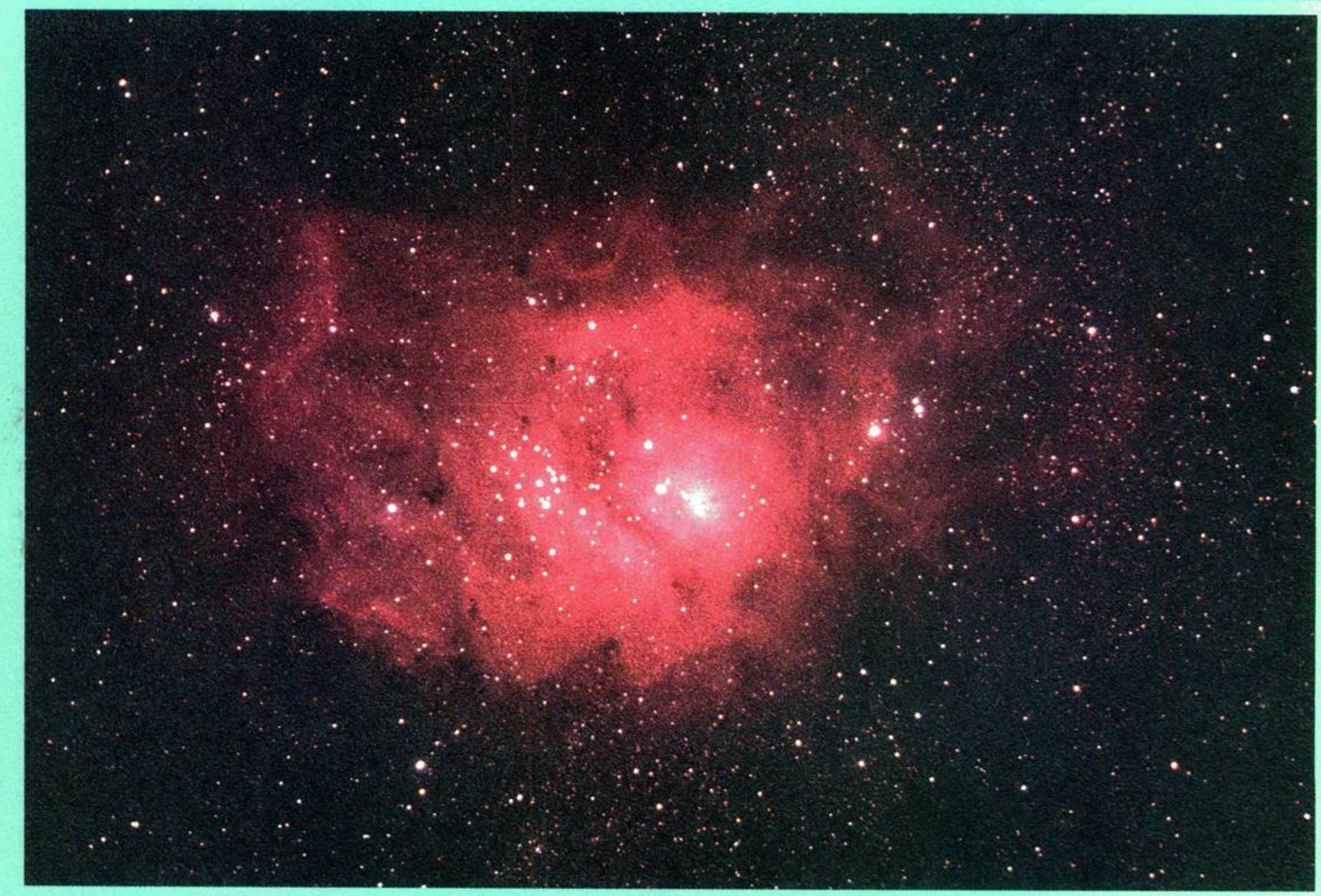

C8 *Photo* *Lagoon Nebula* (M8) 30 *Minutes with f/6.3 Accessory* (*Jim Riffle, Astro Works*)

Yes, and not a simple chore. After almost four years of product development and refining by optical and mechanical engineers, we have achieved the desired results.

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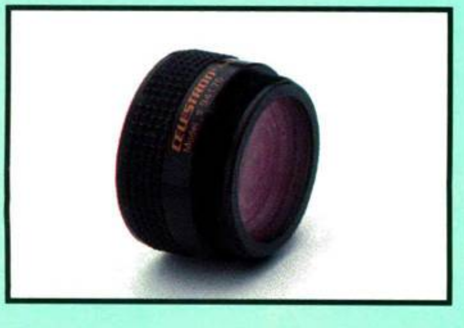
Jim Riffle of Astro Works quotes, "Visually, I used the reducer on the Ultima 8 with a 4mm Ortho while viewing Saturn. At over 300x, it was tack sharp. Cassini's division couldn't have been crisper. At low power the C8 becomes an RFT instrument easily equalling or surpassing coma-corrected Newtonians in full field image quality. Off-axis guiding the C8 with this reducer allowed for numerous, uncommonly sharp guide stars. The low power views through the C14 were awesome!" One of Jim's astrophotos is shown above - compare it to competitive product photos!

reducer/corrector-f/6.3 #94175



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- **f/6.3 (for C8/C11), f/7 (for C14)**
- **Works with all past & present Celestron C8's, C11's & C14's**
- **2-1/2 times reduction in exposure time as compared to f/10**
- **Attaches directly to the rear opening on C8 (to the reducer plate on C11/C14)**
- **Rubber grip for ease of handling in cold weather**

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